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EFFECTS OF SOILS AND GRAZING ON BREEDING BIRDS OF UNCULTIVATED UPLAND GRASSLANDS OF THE NORTHERN GREAT PLAINS

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
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By Harold A. Kantrud
Russell L. Kologiski

UNITED STATES DEPARTMENT OF THE INTERIOR
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Effects of Soils and Grazing on Breeding Birds of Uncultivated Upland Grasslands of the Northern Great Plains

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Abstract

The principal use of uncultivated upland grasslands in the northern Great Plains is for livestock production. However, on lands set aside for wildlife or for scientific or recreational use, grazing by livestock may be used as a management measure to enhance populations of game species or to create conditions that increase the diversity of plant or animal species. To determine the effects of grazing on the avifauna of various types of Great Plains grasslands, we conducted bird censuses and plant surveys during 1974–78 on 615 plots of lightly, moderately, or heavily grazed native rangeland.

Numbers of horned lark (*Eremophila alpestris*), western meadowlark (*Sturnella neglecta*), lark bunting (*Calamospiza melanocorys*), and chestnut-collared longspur (*Calcarius ornatus*) accounted for 65–75% of the total bird population, regardless of grazing intensity. For the entire area sampled (600,000 km²), horned lark, western meadowlark, and chestnut-collared longspur were the dominant birds. Major differences in composition of the dominant species and species richness occurred among the major soils. Increased mean annual soil temperature seemingly had a greater negative influence on avian species richness than did decreased soil moisture or organic matter content. Differences in total bird density were not significant among soils and among grazing intensities within most soils. For the area as a whole, light or moderate grazing resulted in increased species richness. Of the 29 species studied, 2 responded significantly to grazing for the area as a whole and 6 others to grazing on the soil in which peak densities occurred. Response of several other species to grazing effects evidently varied among strata.

A list of plants with mean cover values of more than 1% in any of the 18 combinations of soils and grazing intensities contained less than 25 species, attesting to the relative simplicity of the grassland vegetation in the northern Great Plains. *Agropyron* spp. and *Bouteloua gracilis* were the dominant plants that provided greater than average cover on the best habitat for the most bird species. Optimum habitat for each bird species is given in terms of grazing, soils, and dominant plant species. Increased soil temperature probably had a negative effect on plant species richness, especially among soils with a high organic matter content that supported perennial grasses and other mesophytes.

Originally, native grassland was predominant over nearly all of the vast Great Plains, as mapped by Fenneman (1931). Huge areas of the native range were supplanted by cropland, especially in the cooler, moister soil areas of the east and north. Agriculture is now expanding into the more xeric portions of the area, and recent energy developments pose additional threats to many remaining native grasslands.

Nevertheless, the principal use of upland grasslands of the Great Plains continues to be pasturage for domestic livestock. The effects of livestock grazing on various plant communities of the Great Plains are fairly well known. The effects on the avian community, in contrast, have been studied intensively in only a few areas of Canada (Maher and Felske 1970; Maher 1973; Owens and Myres 1973; Karasiuk et al. 1977) and the United States (Ryder 1970; Ryder and Strong 1971; Wiens 1973) and extensively across only a single State, North Dakota (Kantrud 1981). These studies revealed that grazing by domestic livestock often has pronounced effects on avian species richness and the density of individual species, and also that these effects vary in different areas of the Great Plains.

Proper management of most publicly and privately owned native range is usually directed toward maximizing livestock production without adversely affecting range condition. However, on lands dedicated to wildlife production, grazing is considered a useful management technique for enhancing production of game species or increasing species diversity.

This study was part of an effort to develop a classification of native grasslands as used by breeding birds. Field studies were conducted on 615 plots of uncultivated upland native grassland and shrubsteppe during late spring and early summer 1974–78 in the portion of the northern Great Plains that lies within the United States (Fig. 1). The study area (about 600,000 km^2) includes portions of Montana, Wyoming, Colorado, North Dakota, South Dakota, and Nebraska. Grasslands in the mountains, badlands, sand deposits, and river valleys (shown in white on Fig. 1) were not sampled and are excluded from further consideration.

This report has been prepared for land managers who need information on the effects of grazing on breeding birds in various areas of the Great Plains. Information is also presented on specific plant dominants that were associated with highest densities of each bird species and the apparent response of the dominant plants to grazing intensity on major soils.

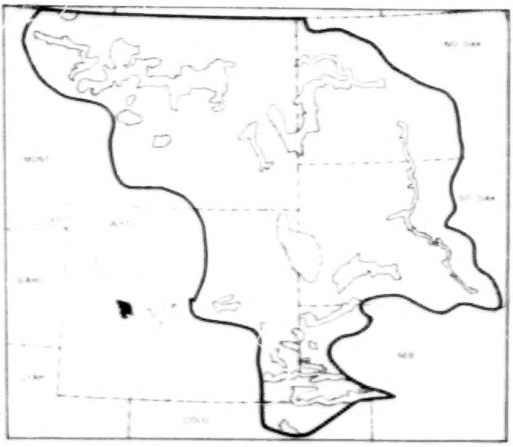

Fig. 1. Outline of northern Great Plains study area. Inset shows position of study area on North American continent. Study area boundaries are as follows: north, border between United States and Canada; east, eastern edge of Missouri Coteau (modified slightly from Fenneman 1931); south, Keya Paha River, Niobrara River, Nebraska Sandhills, and South Platte River; and west, western edge of Great Plains as mapped by A. R. Aandahl. Areas in white within study area were not sampled (see text).

Methods

Selection of Sample Units

Several methods were used to select the sample plots (Fig. 2) during the study. In 1974, plots were selected in numbers proportional to the sizes of the areas of the several mapped physiographic landforms in North Dakota (U.S. and North Dakota Geological Survey maps). Avian use of grasslands developed over these landforms in North Dakota was reported by Kantrud (1981), but of these only those plots lying within the Great Plains are included in the present study. Sample unit locations were initially selected at random from numbered legal townships (93.2 km^2), sections (259 ha), and quarter sections (65 ha). However, differential rates of agricultural disturbance of grasslands among the landforms prevented the maintenance of randomness. If a selected area was devoid of native grassland, the nearest usable plot was chosen.

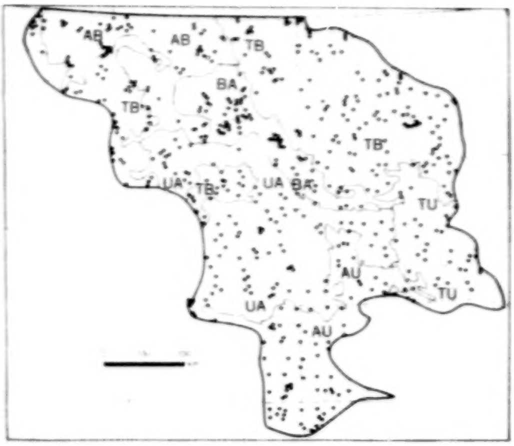

Fig. 2. Location of soils (A. R. Aandahl, map) and sample plots. Some dots represent more than one plot. Soils coded as follows: TB = typic borolls; TU = typic ustolls; AB = aridic borolls; AU = aridic ustolls; BA = borollic Aridisols; UA = ustic Aridisols.

Many plots were rejected because field examination revealed old furrows, rock piles, plantings of domestic grass, or other evidence of past cultivation. Although most of the plots studied in 1974 were legal quarter-sections (65 ha), several were as large as a section or as small as 16 ha. Most plots were square, but occasionally it was necessary to use odd-shaped areas.

In 1975, in Montana and Wyoming, sample units were randomly selected from consecutively numbered townships, in proportion to the area of grassland types mapped by Küchler (1964). After a township was selected and found to lie entirely within the Küchler type, one of a set of 27 possible clusters of four quarter-sections within the township was selected at random. In the field, the usable quarter-section nearest to each of the four cluster elements was censused.

In 1976, in Colorado, Montana, Nebraska, and South Dakota, single quarter-section sample units were selected in proportion to the areas of grassland types 64, 65, and 66 of Küchler (1964). Acceptable plots nearest to the southwest corner of every eighth township in South Dakota and every fourth township in the other States were censused.

In 1977 and 1978 the entire study area was sampled. Quarter-section sample units were subjectively chosen in numbers proportional to the areas of major soil groups mapped by A. R. Aandahl (map).

On a local scale, grasslands not considered typical of general area soils were rejected. These included expanses of wet meadow and rocky hilltops.

Bird Censuses

A single bird census was conducted on each plot between sunrise and sunset when temperatures did not exceed 32° C, precipitation did not occur, and sustained wind velocities did not exceed 24 km/h. Fieldwork was conducted by two teams, each consisting of a botanist and an ornithologist. Census dates were as follows: 1974, 22 May to 19 July; 1975, 29 May to 18 July; 1976, 23 May to 14 July; 1977, 24 May to 13 July; and 1978, 22 May to 2 July. Censuses were usually not conducted between 1200 and 1300 h.

Comparison of five 3-h time periods (0600-2100) in our study showed that (1) of 29 species censused, peak densities for one or more species occurred during each of the five periods, (2) peak densities for 11 species occurred during the 0900- to 1200-h period, and (3) observed total density decreased by up to 25% during counts conducted after the 0600- to 0900-h period. Temporal variation in bird counts undoubtedly biased density indices for some species but was not considered a serious problem because of its random nature as applied to our censuses.

Analyses based on single bird censuses are not recommended during intensive studies where population estimates are required. Nevertheless, they have been used successfully to derive indices to populations or multispecies diversity measurements during extensive surveys (Robbins and Van Velzen 1967; Stewart and Kantrud 1972; U.S. Department of the Interior and Canadian Department of the Environment 1977; Rotenberry 1978; Kantrud 1981). Speirs and Orenstein (1967) showed that, in open Ontario habitats, average efficiency of single censuses is only 66-76% that of 6-10 temporally spaced censuses in estimating breeding populations, but we felt justified in basing indices to bird density on single counts in the grassland habitats because most of the species have behavioral adaptations – including lengthy, loud, and often elaborate flight songs, perch songs, and synchronous display – that tend to greatly increase their detectability compared with birds inhabiting wooded areas. Furthermore, birds are rather easily flushed in grasslands, and the large areas of the sample

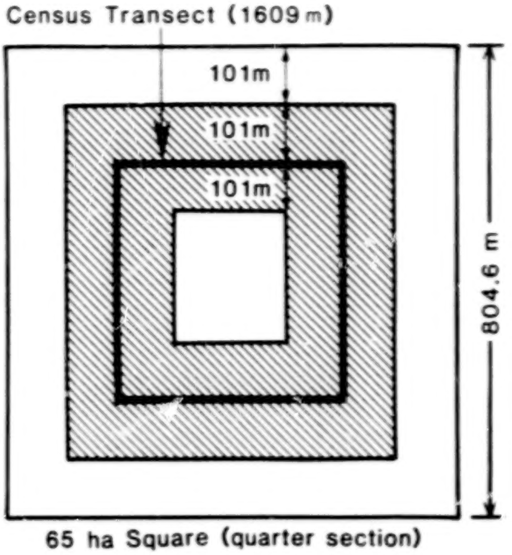

Fig. 3. Quarter-section sample plot showing transect route (heavy line). Shaded area censused = 31.5 ha.

plots resulted in relatively high absolute numbers of bird observations per plot.

We attempted to compensate for phenological differences across the northern Great Plains by beginning the surveys in southerly areas of low elevation. As the breeding season progressed, we moved to regions of successively higher latitude and elevation.

All species were identified in the field by sight or sound. Counts were based primarily on numbers of pairs as indicated by territorial males or segregated pairs. Each male blackbird (polygynous) or brown-headed cowbird, *Molothrus ater* (promiscuous), was considered to represent a pair. Single raptors, grouse, shorebirds, and nighthawks observed on a sample plot were considered to represent a pair, but if more than one was seen, the total was halved and rounded to the nearest lower integer. Additional details on determination of breeding status were described by Stewart and Kantrud (1972). Bird names, which are from the checklist of the American Ornithologists' Union (1957) and its several supplements, are shown in Table 1.

The "hollow square" technique of Speirs and Orenstein (1967) was used on the standard 65-ha plots; the 1,609-m transect route lay 202 m inside the boundary (Fig. 3). Birds were counted within 101 m of the route, yielding an areal coverage of 31.5 ha. Transect routes were variable on the few plots of other sizes and shapes. The verges of many plots bordered other habitat types, so to reduce the influence on the counts of birds occupying fence lines or adjacent habitats, we restricted census transects to the interior of each plot, except for the few plots < 65 ha in area.

Transects were walked at a standard speed of 40 m/min. To allow standardization of data from plots or transects of unequal size and shape, we used expression of bird density in units of time, similar to other extensive studies (e.g., Grinnell and Storer 1924; Skinner 1975). Our indices to bird density were expressed in pairs/min × 10^3. For comparisons with vegetation data, optimum habitat for bird species was considered to occur on those plots in the upper tercile group for observed species density. Terciles are defined as points dividing the distribution of values (pairs/min × 10^3 among the sample units) into thirds.

Soils

Soil development is the result of interactions through time among climate, biological activity, parent materials, and topography (U.S. Soil Conservation Service 1975). Soils in the eastern part of the study area have accumulated more organic material than those in the western part (excluding the foothills) because of greater annual precipitation, lower soil temperature, and greater percentage of precipitation that occurs during the growing season. Parent materials underlying soils over most of the northern Great Plains are residuum from relatively old marine and continental sediments, but soils in portions of the Dakotas and northern Montana have developed over more recent glacial sediments (Bluemle 1977). Topographic relief is low over most of the study area; it probably was not a significant factor in the development of the major soils that now occur there.

A flexible, hierarchical system of soil taxonomy has been developed for the United States (U.S. Soil Conservation Service 1975) and is used here. Upland soils of the study area are primarily of two orders, the Mollisols and Aridisols. Mollisols are characterized by dark-colored surface horizons that are rich in organic matter and contain adequate moisture to support stands

Table 1. *Density indices (mean pairs/min × 10^3) of breeding grassland birds among major soils of the northern Great Plains. Number of plots in parentheses; T = trace (<0.05).*[a]

	Mollisols						
	Typic		Aridic		Aridisols		All soils (means) (615)
Species	Borolls (212)	Ustolls (39)	Borolls (89)	Ustolls (77)	Borollic (68)	Ustic (130)	
Ferruginous hawk							
Buteo regalis	T	1	0	1	T	1	T
Marsh hawk							
Circus cyaneus	4^{W}	3^{WX}	5	1	2^{WX}	1^{X}	3
Sharp-tailed grouse							
Pedioecetes phasianellus	3	3	1	T	T	2	2
Sage grouse							
Centrocercus urophasianus	T^{X}	0^{X}	1^{WX}	0^{X}	1^{WX}	3^{W}	1
Killdeer							
Charadrius vociferus	11	12	7	7	5	7	9
Mountain plover*							
Charadrius montanus	0	0	0	3	0	T	T
Long-billed curlew*							
Numenius americanus	2	2	2	3	1	T	2
Upland sandpiper							
Bartramia longicauda	9^{X}	31^{W}	1^{Y}	6^{XY}	4^{XY}	6^{XY}	8
Mourning dove							
Zenaida macroura	6^{Y}	22^{WX}	6^{Y}	24^{W}	10^{XY}	12^{XY}	11
Burrowing owl							
Athene cunicularia	1	0	2	4	T	T	1
Common nighthawk							
Chordeiles minor	2	2	3	4	1	2	2
Horned lark*							
Eremophila alpestris	180	117	341	331	487	174	251
Sage thrasher*							
Oreoscoptes montanus	1	0	T	T	1	11	3
Sprague's pipit							
Anthus spraguei	19^{W}	2^{X}	19^{W}	T^{X}	2^{X}	3^{X}	10
Common yellowthroat							
Geothlypis trichas	4^{W}	0^{X}	T^{X}	0^{X}	0^{X}	0^{X}	1
Bobolink*							
Dolichonyx oryzivorus	4	69	0	0	0	0	6
Western meadowlark							
Sturnella neglecta	165^{Y}	269^{W}	110^{Z}	123^{Z}	280^{W}	203^{X}	179
Red-winged blackbird							
Agelaius phoeniceus	7^{X}	14^{W}	0^{Y}	0^{Y}	0^{Y}	0^{Y}	3
Brewer's blackbird							
Euphagus cyanocephalus	11^{W}	0^{X}	9^{WX}	2^{X}	5^{WX}	9^{WX}	8
Brown-headed cowbird*							
Molothrus ater	31	70	8	8	8	6	19
Lark bunting*							
Calamospiza melanocorys	56	266	110	123	186	130	116
Savannah sparrow							
Passerculus sandwichensis	16^{W}	3^{X}	5^{X}	0^{X}	T^{X}	T^{X}	6
Grasshopper sparrow*							
Ammodramus savannarum	65	303	10	42	51	19	58
Baird's sparrow*							
Ammodramus bairdii	49	6	24	9	3	T	21
Vesper sparrow							
Pooecetes gramineus	37^{X}	1^{Y}	48^{WX}	3^{Y}	59^{W}	65^{W}	40
Clay-colored sparrow							
Spizella pallida	34^{W}	1^{X}	T^{X}	0^{X}	0^{X}	0^{X}	12
Brewer's sparrow							
Spizella breweri	16^{Y}	0^{Y}	90^{X}	18^{Y}	107^{X}	143^{W}	63

Table 1. Continued

	Mollisols				Aridisols		All soils
	Typic		Aridic				
Species	Borolls (212)	Ustolls (39)	Borolls (89)	Ustolls (77)	Borollic (68)	Ustic (130)	(means) (615)
McCown's longspur *Calcarius mccownii*	72^{Y}	0^{Y}	241^{W}	144^{X}	79^{XY}	20^{Y}	91
Chestnut-collared longspur *Calcarius ornatus*	506^{W}	451^{WX}	303^{X}	125^{Y}	358^{X}	68^{Y}	317
Total density (mean no. birds/plot)	1,309	1,648	1,349	971	1,653	887	1,243
Species richness (mean no. species/plot)	6.72^{W}	6.33^{WX}	6.44^{WX}	4.36^{Z}	5.88^{XY}	5.44^{Y}	6.00

*For species followed by an asterisk, F-tests revealed significant interaction between the independent variables (soil and grazing regime). Means with one or more superscript letters (WXYZ) in common are not significantly ($P = < 0.05$) different.

of perennial grasses and other mesophytes (Fig. 4). Aridisols are light-colored soils, low in organic carbon, with moisture regimes suited to xerophytes. The six soils on which the study plots were located (Fig. 2) correspond to combinations of soil suborders and great groups mapped and classified by A. R. Aandahl (map). The soils are differentiated primarily on combinations of soil temperature, moisture content during the growing season, and organic matter content (Fig. 4). For convenience, we named the soils after the major suborder in the categories mapped by A. R. Aandahl (map); other closely related soil taxa occur within the areas shown in Fig. 2.

Vegetation Surveys

A rapid field reconnaissance of the vegetation was conducted immediately after the bird census on each plot. On the basis of visual estimation, an areal cover index was assigned to each identified species on the plot. The cover classes (and range of cover in percent) in each class were as follows: 1 (0–1), 2 (1–10), 3 (10–25), 4 (25–50), 5 (50–75), 6 (75–90), 7 (90–100). Class midpoint values were used in the analysis. The average height of the vegetation was estimated visually in the field on 156 plots and later from photographs of 150 plots. The percentage of bare soil was estimated in the field on 462 plots. Scientific names and taxonomic order of plants follow the Atlas of the Flora of the Great Plains (Great Plains Flora Association 1977).

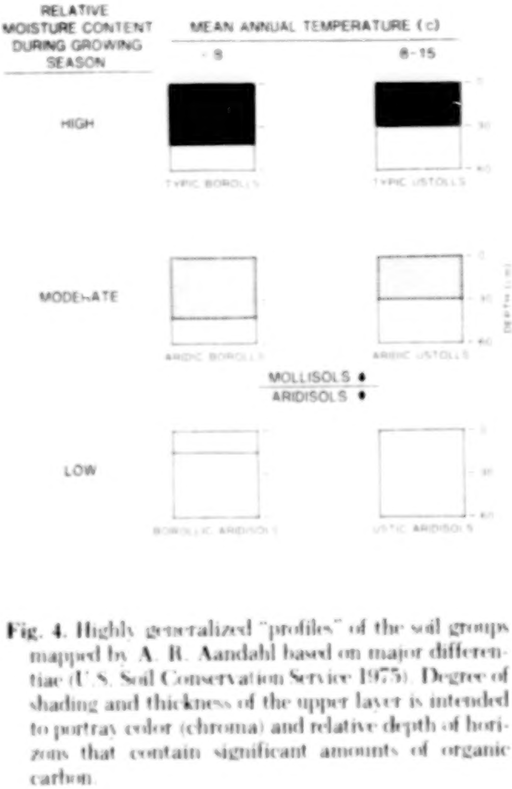

Fig. 4. Highly generalized "profiles" of the soil groups mapped by A. R. Aandahl based on major differentiae (U.S. Soil Conservation Service 1975). Degree of shading and thickness of the upper layer is intended to portray color (chroma) and relative depth of horizons that contain significant amounts of organic carbon.

Grazing Intensity

Grazing intensity was estimated by comparing the percentage of bare soil, amount of standing and fallen dead vegetation, and average vegetative height on the study plots with that of nearby protected or ungrazed areas. On the basis of this information, we placed plots into the three subjective categories of heavily, moderately, and lightly grazed. Distribution of the 615 plots among grazing categories was as follows: heavy, 197; moderate, 241; and light, 177. Any plots lacking evidence of livestock use were not censused. Most of the plots were grazed by cattle but a few were used for sheep, bison, or horses. A few plots contained various combinations of domestic livestock and horses. Plots in each grazing category were well distributed among the strata.

Data Analysis

We subjected indices for bird densities and number of species per plot (richness) for soils and grazing regimes to analysis of variance (ANOVA) using the General Linear Models Program of Statistical Analysis System 76 (Barr et al. 1976). Differences were declared significant at the $P = 0.05$ level. We used Duncan's (1955) Multiple Range Test to determine which means differed significantly. For analyses involving the entire study area, effects of both input variables (soil and grazing regime) were considered (Type IV F-tests of Barr et al. 1976). The effects of soil were also considered conditional on grazing regime but the effect of grazing was analyzed separately for each soil.

Examples of the analysis of variance are presented here for two species to show how the presence or absence of interaction between the two input variables could affect the results of the study. The horned lark (Fig. 5) showed highly significant interaction between the variables. Mean density varied moderately among soil taxa and greatly among grazing intensities. Most of the interaction could be attributed (1) to the typic ustolls where heavily grazed plots were more favored than moderately or lightly grazed areas, and (2) to the highly disproportionate use of the borollic Aridisols, where densities on heavily grazed areas were nearly twice those found on any other combinations of soil and grazing regime. Because of the strong interaction, statements concerning density differences due to grazing could be made only for individual soil taxa.

In contrast, the western meadowlark (Fig. 6) showed no significant interaction between the variables. Mean density did not vary greatly among soils and grazing intensities, but tests of the effects of both variables were significant. Within soils, the response to grazing intensity was relatively small, but for the study regions as a whole, significant differences in density of western meadowlark were found among soils, grazing intensities within soils, and among grazing intensities. Influence of increased soil temperature was moderately positive in the typic Mollisols, nearly neutral in the aridic Mollisols, and moderately negative in the Aridisols.

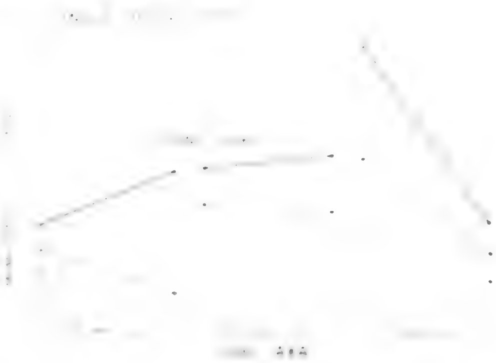

Fig. 5. Density of horned lark in relation to different combinations of soils and grazing intensities. Endpoints of the solid, long-dashed, and short-dashed lines represent densities recorded under heavy, moderate, and light grazing, respectively.

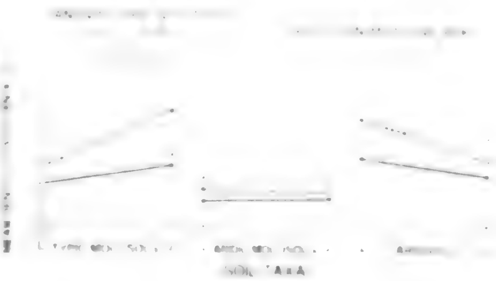

Fig. 6. Density of western meadowlark in relation to different combinations of soils and grazing intensities. Endpoints of the solid, long-dashed, and short-dashed lines represent densities recorded under heavy, moderate, and light grazing, respectively.

Results

Descriptions of Breeding Habitat

The following accounts list the evident optimum breeding habitat for each of 29 bird species

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[illegible] grazing [illegible]. Plants exhibited [illegible] intensity, and [illegible]. Plant species more [illegible] than those associated with plots supporting highest densities of the bird species. Plants that were among the 10 highest in cover values or occurred in greater than average abundance compared with the study area as a whole are mentioned. Comparative comments from the literature are also reviewed.

Ferruginous Hawk

Ferruginous hawks were usually seen while they were hunting. Densities were highest on heavily grazed typic borolls (Table 2). Their association with well-grazed plots probably reflects the larger mammalian prey populations in these areas, particularly where Richardson's ground squirrels (*Spermophilus richardsonii*) were abundant. In Oregon grasslands, the abundance of ground squirrels (*S. townsendii*) strongly influenced the distribution of ferruginous hawks. Ground squirrel distribution there was related to soil characteristics; coarse, loamy soils that lacked duripan horizons and a high clay content supported the most squirrels ([illegible] 1980). These soil characteristics also applied to many of the typic borolls we studied.

Heavily grazed or extremely flat areas are undesirable for the ground nests ([illegible] 1972, Stewart 1975, Lokemoen and Duebbert 1976). Generally, a large variety of elevated situations [illegible] trees, rock piles, [illegible], electric powerline structures, and haystacks provide suitable nest sites.

The cover values of *Carex filifolia*, *Agropyron* spp., *Bouteloua gracilis*, and *Artemisia frigida* were above average on the four plots where ferruginous hawks were observed.

Marsh Hawk

We encountered greatest numbers of marsh hawks where grazing was light to moderate on the cool northern boroll soils. The birds we saw were probably feeding and nesting. No other investigators have compared marsh hawk populations under various degrees of grazing, but Duebbert and Lokemoen (1977) found more nests on idle domestic grasslands than on annually grazed prairie in South Dakota.

Upland nests of marsh hawks in the northern Great Plains have been associated mostly with the shrub *Symphoricarpos occidentalis* ([illegible] 1951, 1918, [illegible] 1925, Sealy 1967, Renaud and Renaud 1975, Stewart 1975, Salt and Salt 1976). Other shrubs or small trees attractive to the species in this region include members of the genera *Salix* (Breckenridge 1935), *Potentilla* (Saunders 1913), *Rosa* (Williams and Matteson 1947, Sealy 1967, Renaud and Renaud 1975, Stewart 1975, Salt and Salt 1976), and *Elaeagnus* (Renaud and Renaud 1975, Stewart 1975). Idle tall grasses or tall forbs also provide upland nesting cover (Newell 1950, Sealy 1967, Clark 1972, Duebbert and Lokemoen 1977).

The abundance of *Selaginella densa* and *Carex eleocharis* was above average on plots containing the most marsh hawks. The only shrub occurring in much greater than average abundance on these plots was *Rosa woodsii*.

Sharp-tailed Grouse

For the entire sample, the density of sharp-tailed grouse decreased progressively as grazing intensity increased. Density was highest on the typic ustolls under moderate grazing and on the typic borolls under light grazing. Density was never high where grazing was heavy on any of the soils.

The detrimental effect of heavy grazing on sharp-tailed grouse throughout the northern Great Plains has been well established (Aldous 1943, Kobriger 1965, Evans 1968, Bernhoft 1969, Pepper 1972, Hillman and Jackson 1973, Yde 1977, M. C. Hammond unpublished data; L. M. Kirsch unpublished data) and Kirsch et al. (1978) considered even lightly grazed areas to be of only limited importance to the species compared with idle areas. Mattise (1978) found better habitat quality associated with non-uniform removal of vegetation by livestock. Best nesting cover usually contains relatively tall, dense vegetation (Brown 1966, Christenson 1971, Kohn 1976, Sisson 1976) but its species composition probably is not important (Kirsch 1974).

Grasses with above average cover value on nine plots with high sharp-tailed grouse densities included *Agropyron spicatum*, *Koeleria pyramidata*, *Poa pratensis*, *P. sandbergii*, and *Stipa viridula*, all of which generally decreased as grazing pressure intensified (Table 3). Other plants with higher than average cover on these plots were *Rosa arkansana*, *Symphoricarpos occidentalis*, and *Chrysopsis villosa*.

Sage Grouse

The sage grouse was an important species only on the ustic Aridisols where *Artemisia tridentata* was the dominant plant. Densities probably were greatest under light and moderate grazing; overgrazing was generally detrimental to sage grouse (Girard 1937; Rasmusson and Griner 1938; Patterson 1952; Rogers 1964).

On five tracts with upper tercile sage grouse densities, *Agropyron spicatum*, *Koeleria pyramidata*, and *Poa sandbergii* were present in above average amounts. Non-graminoids of greatest importance were (in decreasing order of abundance) *Artemisia tridentata*, *A. cana*, *Opuntia polyacantha*, *Chrysopsis villosa*, and *Atriplex nuttallii*.

Killdeer

Densities of killdeers were significantly higher where grazing was heavy than where it was moderate or light throughout the northern Great Plains area. They were about equally high under heavy grazing on the typic borolls and ustolls. The preference of killdeers for relatively bare, unvegetated areas near water was reported by Bunni (1959). However, other authors (Tyler 1913; Neilson 1923; Furniss 1933; Bailey and Niedrach 1965) have indicated that the presence of open water is not required.

Important plants occurring in above average abundance on plots supporting high killdeer densities were *Carex eleocharis*, *Agropyron* spp., *Bouteloua gracilis*, *Buchloe dactyloides*, *Poa pratensis*, and *P. sandbergii*.

Mountain Plover

A relatively uncommon species in the northern Great Plains area, the mountain plover was most abundant in heavily grazed areas on the aridic ustolls. It was found to be associated with heavily grazed or sparsely vegetated areas by Roosevelt (1885), Hoskin (1893), Soper (1941), Finzel (1964), Giezentanner (1970), Boyd (1974), Graul and Webster (1976), and Wallis and Loewen (1980). However, extreme or long-term overgrazing may be detrimental to the species (Laun 1957; Wallis and Wershler 1981), and mountain plovers occasionally use idle areas (Lohoefener 1978) or rangeland in fair condition (Lock 1975).

C. J. Knowles et al. (unpublished data) found a close relation between mountain plover and black-tailed prairie dogs (*Cynomys ludovicianus*) in Montana and considered grazing by both cattle and prairie dogs to be an essential habitat factor.

Two general vegetation types seem to be occupied by mountain plovers in the northern Great Plains: the gently rolling *Bouteloua–Buchloe* or *Bouteloua–Carex* grasslands (Bradbury 1918; Laun 1957; Finzel 1964; Giezentanner 1970; Graul 1975; Wallis and Loewen 1980; Wallis and Wershler 1981) and desertlike areas containing mostly cactus and low shrubs interspersed with alkali flats and claypans (Roosevelt 1885; Warren 1912; Soper 1941).

We obtained data from only two plots with upper tercile densities of mountain plover; dominant plants there (in decreasing order of average abundance) were *Bouteloua gracilis*, *Buchloe dactyloides*, *Opuntia polyacantha*, *Agropyron* spp., and *Aristida longiseta*.

Long-billed Curlew

We found highest densities of long-billed curlews under lightly grazed conditions on the aridic ustolls, and fairly high concentrations on lightly grazed aridic borolls and heavily grazed typic ustolls. This once widespread species apparently now has disjunct populations in western South Dakota and the north-central Montana grasslands. The northern population, which inhabits the aridic borolls, probably is *Numenius americanus parvus*; the southern group, which is found on ustolls, is probably *N. a. americanus*.

Although several investigators have indicated that the long-billed curlew prefers grazed areas (Silloway 1900, 1902; Cole and Sharpe 1976; Bicak 1977; King 1978; Pampush 1980), none have compared population densities under different degrees of grazing. Timken (1969) found it in both pastureland and unoccupied fields. King (1978) found six of a group of seven nests in flat grazed pastures dominated by shortgrasses (*Bouteloua gracilis* and *Buchloe dactyloides*) and two other nests in fallow cropland; however, areas of rangeland were used in greater proportion than their availability. Pampush (1980) found that both adults and adults with broods apparently preferred habitats with low vertical profile and density; highest nest densities occurred in grazed areas dominated by *Bromus tectorum*, *Poa pratensis*, and *Opuntia polyacantha*. Allen (1980) attributed the selection of *Bromus tectorum*–*Poa sandbergii* habitat to its short height which allowed adults better visi

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Table 2. Density indices (mean pairs/km² × 10²) of breeding grassland birds among grazing intensities (L = light, M = moderate, H = heavy) within major soils of the northern Great Plains. Number of plots in parentheses. T = trace (< 0.5).

	Mollisols												Aridisols						Northern Great Plains		
	Typic						Aridic												All soils average		
	Borolls			Ustolls			Borolls			Ustolls			Borollic			Ustollic					
Species	L (67)	M (56)	H (66)	L (14)	M (17)	H (8)	L (21)	M (37)	H (31)	L (20)	M (28)	H (20)	L (21)	M (26)	H (21)	L (34)	M (77)	H (51)	L (177)	M (241)	H (197)
Ferruginous hawk	0	1	1	0	2	0	0	0	0	0	1	1	0	1	0	0	1	1	0	1	1
Marsh hawk	5	4	2	4	1	1	5	6	5	0	1	1	1	3	2	0	2	0	3	2	2
Sharp-tailed grouse	5	2	5	2	7	0	3	1	0	1	0	0	1	0	0	2	2	1	3	2	1
Sage grouse	0	1	0	0	0	0	0	2	2	0	0	0	0	0	2	1	4	2	1	1	1
Killdeer	7	6	17	5	14	21	4	9	6	4	3	13	4	7	8	2	9	10	5	9	12
Mountain plover*	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	1	0	1	1	1	1
Long-billed curlew*	1	1	7	2	0	6	5	1	1	10	0	2	0	2	0	1	1	0	2	1	1
Upland sandpiper*	8	3	8	20	41	19	0	1	2	11	2	6	1	1	10	5	5	10	8	7	8
Mourning dove	7	4	8	4	31	38	6	5	8	20	27	23	18	10	2	12	10	14	10	11	12
Burrowing owl*	1	1	1	0	0	0	1	2	1	3	3	5	0	0	2	3	1	0	1	1	2
Common nighthawk	2	2	1	0	3	3	3	4	3	2	2	9	2	2	0	1	2	2	2	2	3
Horned lark	113	170	252	200	300	414	265^{Y}	314^{Y}	424^{X}	200^{Y}	292	450^{X}	235^{Z}	451^{Y}	384	83	168	204	142	226	375
Sage thrasher*	1	1	0	0	0	0	0	0	1	0	0	1	2	1	1	14	5	1	4	2	3
Sprague's pipit	22	23	11	0	2	5	28	25	6	0	0	0	0	5	0	7	2	1	13	12	5
Common yellowthroat	0	2	0	0	3	0	0	1	0	0	0	0	1	0	0	0	0	0	3	1	0
Bobolink*	6	3	2	17	28	0	0	0	0	0	0	0	0	0	0	0	0	0	15	5	1
Western meadowlark	207	211	124	214	150	180	147	113	80	202^{X}	106	85	301	122	207	268^{X}	190	133	210	190^{X}	130
Red-winged blackbird	12	63	7	7	22	7	0	0	0	0	0	1	0	0	0	0	0	[illegible]	5	3	1
Brewer's blackbird	4	13	10	0	0	0	5	8	14	0	5	1	3	6	4	8	10	10	4	6	10
Brown-headed cowbird*	11	25	30	40	108	41	10	5	9	3	2	17	1	4	20	5	5	6	18	18	22
Lark bunting*	65	60	42	193	203	401	33	170	109	212^{X}	140^{XY}	44^{Y}	172	175	218	155	120	123	118	125	102
Savannah sparrow	21	20	6	5	1	0	5	8	1	0	0	0	0	1	0	0	1	0	6	8	2
Grasshopper sparrow*	151	45	100	151	285	82	17	14	0	74	47	14	78	52	25	34	20	6	113	52	16
Baird's sparrow*	78	38	32	4	5	0	33	34	7	0	0	0	7	2	0	1	0	0	35	18	12
Vesper sparrow	29	40	11	2	1	0	57	46	43	1	3	3	62	85	25	81	64	50	41	47	31
Clay-colored sparrow*	50	29	25	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	19	9	9
Brewer's sparrow	12	28	6	0	0	0	52	114	88	26	17	14	95	117	109	202^{X}	124^{X}	110	64	70	53
McCown's longspur	40	65	70	0	0	0	182	210	318	97	229	95	44	18	100	1	40	9	55	99	113
Chestnut-collared longspur	406	484	534	472	358	570	223	370	279	240	400	62	307	268	331	58	67	83	82	208	380
Total density (mean no. birds/plot)	1,625	1,298	1,307	1,625	1,590	1,295	1,085	1,450	1,406	1,105	987	963	1,424	1,530	2,034	943	861	870	1,234	1,228	1,269
Species richness (mean no. species/plot)	7.04	6.86	6.22	5.57	7.18	5.88	6.29	6.02	5.97	4.65	4.11	4.41	5.81	5.31	5.43	5.21	5.59	5.46	6.07^{X}	6.22^{X}	5.66^{Y}

For species followed by an asterisk (*) F-test showed significant interaction between the independent variables soil and grazing regime across the northern Great Plains. Means with one or more superscript letters (XYZ) in common are not significantly ($P < 0.05$) different.

[illegible]

Table 4. *Average height of vegetation and percentage of bare soil (in parentheses) among grazing intensities within major soils of the northern Great Plains.*[a]

	Mollisols				Aridisols	
	Typic		Aridic			
Grazing intensity	Borolls	Ustolls	Borolls	Ustolls	Borollic	Ustic
Light	30 (5)	28 (3)	25(15)	23 (9)	17 (6)	28(15)
Moderate	23 (8)	23 (8)	20(17)	18(11)	13 (8)	20(17)
Heavy	17(12)	18(13)	8(25)	10(17)	5(13)	15(24)

[a] Height (cm) based on visual estimates from 156 plots and 172 photographs of 150 plots; bare soil percentages based on visual estimates from 462 plots.

bility of approaching danger. Both Sugden (1933) and Timken (1969) suggested that domestic sheep have a detrimental effect on nests of the long-billed curlew, but that cattle do not. Our data indicated that the birds generally preferred lightly grazed areas on aridic soils and heavily grazed areas on the moister typic soils. This finding is supported by observations in Saskatchewan, which indicated that the long-billed curlew uses both moist and dry grasslands but may not occupy moist fescue grasslands containing excessive vegetation (Renaud 1980).

Of the most important plants on areas where the long-billed curlew was abundant, *Selaginella densa*, *Bouteloua gracilis*, *Artemisia frigida*, and *Chrysopsis villosa* occurred in greater than average amounts (Table 4). Other common plants associated with better quality habitat for this species were *Agropyron spicatum*, *Calamovilfa longifolia*, and *Festuca idahoensis*.

Upland Sandpiper

Densities of upland sandpiper were highest on the typic ustolls, on moderately grazed plots. Upland sandpipers were denser on grasslands on this soil than on any of the other soils, regardless of grazing intensity. In general, density of this species showed little relation to grazing intensity.

Results of other studies tend to confirm that grazing may be relatively unimportant to nesting populations of the upland sandpiper over much of its range. Although some studies have indicated that grazing might be detrimental (Buss and Hawkins 1939; Rand 1948; Mitchell 1967; Wiens 1973; Ailes 1976; Kirsch and Higgins 1976), Lokemoen and Duebbert (1974) and Skinner (1975) found high populations in moderately grazed areas. Criddle (1912), Rowan (1926), and Bent (1929) recorded nests in heavily grazed or sparse vegetation. Kantrud (1981) found no great differences in density on North Dakota grasslands subject to various intensities of grazing. In areas supporting tallgrass prairie and in the Nebraska Sandhills, grazing or mowing appeared to be beneficial to this species (Kendeigh 1941; Stewart 1975; Ailes 1976; Cole and Sharpe 1976). Habitat use by upland sandpipers must be studied in much greater detail because Ailes (1976) has shown that feeding and brood-rearing areas may be very different from nesting areas.

Of the five dominant grasses on the best upland sandpiper habitat, only *Agropyron* spp. and *Poa pratensis* occurred in amounts much greater than average for the entire study area (Table 4). Of the 10 most important plants of all types on the best habitat, *Artemisia ludoviciana* was the only forb showing increased dominance (Table 4). Other plants in above average amounts in best habitat were (in decreasing order of abundance) *Stipa viridula*, *Buchloe dactyloides*, *Symphoricarpos occidentalis*, and *Aristida longiseta*.

Mourning Dove

Densities of mourning doves were highest where grazing was moderate or heavy, on the typic ustolls. Densities were also consistently above average under all grazing regimes on the aridic ustolls. Soutiere and Bolen (1976) found that ground-nesting mourning doves in Texas seemed to avoid areas with litter. Populations nesting in Iowa tallgrass prairie selected areas of short grass or bare soil between clumps of vegetation (George et al. 1979). In Idaho sagebrush habitat, Reynolds and Trost (1980) found fewer mourning dove nests in grazed than in ungrazed areas; however, in Arizona shrub grassland, Monson (1941) reported that grazing had very little effect on breeding populations. An affinity for areas dominated by short shrubs was recorded by Downing (1957), who found that densities of ground nests were almost four times greater in areas dominated by sand sagebrush (*Artemisia filifolia*) than in pure grasslands in Oklahoma.

On plots containing high mourning dove densities, the only dominant plant occurring in much greater than average abundance was *Bouteloua gracilis* (Table 4), which increases when areas are grazed (Table 3). Less abundant plants that were found in unusually great amounts on these plots were *Aristida longiseta* and *Buchloe dactyloides*, which also respond positively to grazing. The mourning dove showed no great affinity for shrub-dominated areas but the cover of *Yucca glauca* was about twice the average on plots where doves were most numerous.

Burrowing Owl

Optimum habitat of burrowing owls in the study area was heavily grazed grassland on the aridic ustolls. Densities were also fairly high in heavily grazed areas on the typic borolls. The close association of this species with areas heavily grazed by burrowing rodents (Visher 1913; Patton 1926; Hamilton 1941; Longhurst 1942; Lohoefener 1978) or cattle (Roberts 1932; Bue 1955; Butts 1973; Martin 1973) is well known. Zarn (1974) considered openness, short vegetation, and availability of fresh rodent burrows essential for optimum habitat. Gleason (1978) noticed the apparent aversion of the species to habitat dominated by *Artemisia* in Idaho.

Plants showing increased dominance on six plots containing high densities of burrowing owls were *Bouteloua gracilis*, *Buchloe dactyloides*, *Poa sandbergii*, and *Stipa comata*.

Common Nighthawk

Heavily grazed plots on the aridic ustolls supported the densest nighthawk populations. We found no references to the specific effects of grazing on this species, but its preference for bare or sparsely vegetated areas for nesting is well known (Gross 1940). Densities were usually slightly greater in the more arid soil areas. This relation was also noted by Stewart (1975) in North Dakota and by the South Dakota Ornithologists' Union (1978) in South Dakota. It may be caused by diminished habitat availability in the more intensively farmed typic soils.

Best common nighthawk habitat was characterized by high cover values for shortgrasses or species indicative of overgrazing: *Selaginella densa*, *Bouteloua gracilis*, *Buchloe dactyloides*, and *Opuntia polyacantha*.

Horned Lark

Preference for barren grasslands by horned larks for nesting has long been observed (Hayden 1863; Bendire 1895). We found that heavily grazed plots on the borollic Aridisols supported highest densities, and that densities were highest under heavy grazing and lowest under light grazing for all soils. These results agree well with most other studies of the horned lark in the northern Great Plains (Finzel 1964; Giezentanner 1970; Owens and Myres 1973; Wiens 1973; Karasiuk et al. 1977; Kantrud 1981). Reynolds and Trost (1980) also found slightly more nests in grazed than in ungrazed sagebrush habitat in Idaho. Other studies in Colorado (Boyd 1977) and Arizona (Monson 1941) indicated that the apparent preference for heavily grazed areas may not apply to more arid areas. Salt and Salt (1976) stated that lightly grazed pastures may be selected for nesting in Alberta.

Studies by Maher (1972) and Creighton and Baldwin (1974) indicated that the preference of horned larks for grazed areas is related to food availability and foraging behavior. Boyd (1977) considered vegetation type a proximate factor in habitat selection for this species because territories were established before insect foods became available.

Karasiuk et al. (1977), Boyd (1977), and Thompson and Sullivan (1979) mentioned *Bouteloua gracilis* as a dominant plant in areas heavily used by breeding horned larks. In the native fescue (*Festuca scabrella*) grasslands studied by Owens and Myres (1973), *B. gracilis* was present only in plots that contained horned larks. During our study, cover values for *B. gracilis*, *Buchloe dactyloides*, *Poa sandbergii*, and *Opuntia polyacantha* were higher than average on the most heavily populated plots.

Sage Thrasher

The range of the sage thrasher was nearly restricted to the ustic Aridisols where *Artemisia tridentata* dominated the vegetation. Density was highest where grazing was light, although *A. tri* *dentata*, upon which the species seems almost totally dependent, is little affected by grazing (Table 4). We cannot explain why densities were higher under heavy than under moderate grazing, but suspect that more of the moderately grazed plots in which this species occurred were by chance located in areas on the periphery of the range of *A. tridentata* where shorter, sparser growth is prevalent and sage thrashers are not as abundant.

Little other information is available on the effect of livestock on this species. Monson (1941) observed densities more than twice as high on moderately grazed than on overgrazed pastures in Arizona, and found that in moderately grazed areas *Atriplex canescens* provided much denser crown cover. Reynolds and Rich (1978) and Reynolds and Trost (1980) found higher nest densities on a grazed than on an ungrazed area in Idaho but the two sites sampled were small. Nests were closer together in the ungrazed area, but no second nests were found in the area subject to grazing (Reynolds and Rich 1978).

On plots where sage thrashers were densest, *Agropyron* spp., *Carex filifolia*, *Opuntia polyacantha*, and *Artemisia tridentata* were particularly abundant (Table 4). Other plants with greater than average cover value were *Agropyron spicatum*, *Oryzopsis hymenoides*, *Atriplex nuttallii*, *Ceratoides lanata*, *Artemisia cana*, and *A. pedatifida*.

Sprague's Pipit

Densities of Sprague's pipit were greatest on the aridic and typic borolls; light and moderate grazing appeared to be about equally attractive, but heavy grazing was detrimental.

Two early ornithologists in the northern Great Plains noticed the affinity of breeding Sprague's pipit for tall, dense grass (Allen 1874; Hoffman 1877). Later studies in Canada revealed that, although populations in upland areas were highest on lightly grazed or idle lands (Maher and Felske 1970; Maher 1972; Owens and Myres 1973; Karasiuk et al. 1977), heavily grazed areas would attract some birds (Houston 1981). In North Dakota, both moderately and heavily grazed areas were favored over lightly grazed areas (Kantrud 1981). Several observers have also noticed the attractiveness of wetland borders or the edges of alkaline flats for this species (Saunders 1921; Wood 1923; Stewart 1975).

Of the dominant plants on plots supporting highest densities of Sprague's pipit, *Selaginella densa*, *Koeleria pyramidata*, *Stipa comata*, *Artemisia frigida*, and *A. ludoviciana* provided greater than average cover (Table 4). Other plants seemingly indicative of good habitat included *Stipa viridula*, *Rosa arkansana*, *Symphoricarpos occidentalis*, and *Chrysopsis villosa*.

Common Yellowthroat

In upland habitats in the northern Great Plains grassland, the common yellowthroat is almost entirely restricted to the typic borolls in North Dakota. Densities were about equally high in light and moderately grazed areas. An earlier study indicated that densities were greatly reduced by even moderate grazing in North Dakota (Kantrud 1981). Johnson (1972, 1973, 1974) found high densities in idle grasslands in central North Dakota. Stewart (1975) listed dense, mature stands of *Symphoricarpos occidentalis* and *Artemisia cana* as suitable upland nesting habitat for this species in North Dakota. *S. occidentalis* is also used for nest sites in Manitoba and Saskatchewan (Knapton 1979).

Common yellowthroat were found at high densities on only four plots during the present study. Here, mean cover values for the shrubs *Rosa woodsii*, *Amorpha canescens*, and *Symphoricarpos occidentalis* were much greater than average. Other plants with above average cover were *Poa pratensis* and *Stipa viridula*.

Bobolink

Best habitat for the bobolink among the grasslands we studied probably consisted of lightly grazed areas on the typic ustolls of southeastern South Dakota. In areas to the east of the Great Plains this species favors tall, lush vegetation (Lincoln 1925, Bent 1958, Hibbard 1965; Martin 1971) and the presence of litter (Tester and Marshall 1961; Wiens 1969, Hibbard 1972, Potter 1972; Harrison 1974). Populations probably reach much greater densities there, especially in tallgrass prairie (Coues 1878; Kendeigh 1941, Hibbard 1965) or in certain man-made habitats (Potter 1972; Harrison 1974).

Bent (1958) thought that the bobolink followed civilization westward because of the favorable habitat created by the cultivation of forage crops. Much earlier, however, Hayden (1863) characterized the bobolink as one of the most abundant birds of the prairies of the upper Missouri River region. Ungrazed or lightly grazed prairie perhaps became common at a very early date because of reduced ungulate populations along rivers heavily used by European fur trappers or extensively hunted by native Americans. In the more arid portions of its range the bobolink may remain restricted to grasslands along streams and low areas (Silloway 1904, 1917; Saunders 1921; Godfrey 1950).

We seldom recorded the species on heavily grazed plots during our study. Heavily grazed plots occasionally contained a few pairs if wetlands or brush patches were present. Moderately grazed fields are apparently favored over lightly grazed or idle areas in Missouri, where forbs and woody growth may quickly eliminate the grassland aspect (Skinner 1975). Hayland is very attractive to this species if not mowed during the nesting period (Bailey 1915a; Kendeigh 1941; Harrison 1974; Kantrud 1981).

Plants showing greater than average cover values on the nine plots supporting the highest densities of bobolink were *Agropyron* spp., *Poa pratensis*, and *Stipa viridula*.

Western Meadowlark

Density of the western meadowlark was highest on the typic ustolls under moderate grazing intensity. Lightly and moderately grazed plots supported significantly higher densities of western meadowlark than did heavily grazed plots throughout the northern Great Plains area. Heavily grazed areas supported the lowest densities in all soil groups, but this effect was most noticeable on aridic soils.

Several earlier investigations did not support our findings. Owens and Myres (1973) and Karasiuk et al. (1977) in Alberta, and Johnson (1972, 1973, 1974), Hopkins (1980) and Kantrud (1981) in North Dakota found that grazing had little effect on the density of the western meadowlark. Results of other investigations tended to confirm our observations. For example, Maher (1972) reported that western meadowlarks were more than five times more numerous on ungrazed than on grazed prairies in Saskatchewan. Meadowlarks were lacking in heavily grazed areas of shortgrass prairie in Colorado, but nevertheless reached higher densities in moderately than lightly grazed areas (Giezentanner 1970). Monson (1941) recorded high densities on lightly or moderately grazed Arizona pastures containing dense stands of *Agropyron smithii*, but saw no birds on nearby overgrazed areas. Grazing by sheep tended to reduce the numbers of nests in Idaho sagebrush habitat (Reynolds and Trost 1980).

Agropyron spp. and *Artemisia tridentata* showed increased dominance on the best western meadowlark habitat we observed (Table 4). Other species that occurred in amounts greater than averge for the study area were *Agropyron spicatum*, *Buchloe dactyloides*, and *Stipa viridula*.

Red-winged Blackbird

On the uplands we studied, red-winged blackbirds were seen only on the typic Mollisols. Densities were highest where grazing was moderate on the typic ustolls and light on the typic borolls. We found no other information on the effects of grazing on upland nesting populations of this species in the Great Plains. Johnson (1972, 1973, 1974) censused red-winged blackbirds on variously grazed plots in North Dakota mixed prairie, but upland nesters were not separated from those in the wetlands.

Genera of grasses, forbs, or short shrubs known to be associated with upland nesting populations of the red-winged blackbird include *Agropyron* (Holcomb and Twiest 1968; Stewart 1975), *Bromus* (Stewart 1975; Krapu 1978), *Secale* (Tyler 1913), *Triticum* (Tyler 1913), *Kochia* (Stewart 1975), *Ribes* (Sherman 1932), *Rosa* (Provost 1947; Krapu 1978; South Dakota Ornithologists' Union 1978), *Medicago* (Bent 1958; Krapu 1978), *Melilotus* (Hyde 1939b; Holcomb and Twiest 1968; Stewart 1975), *Trifolium* (Hyde 1939b), *Vicia* (Hyde 1939b), *Rhus* (Orians 1961), *Symphoricarpos* (Provost 1947; Bird and Smith 1964; Miller 1968; Stewart 1975; Knapton 1979), *Artemisia* (Orians and Horn 1969), *Baccharis* (Orians 1961), *Cirsium* (Stewart 1975), *Erigeron* (Francis 1973), and *Solidago* (Bent 1958; Speirs and Orenstein 1967; Holcomb and Twiest 1968; Miller 1968; Francis 1973).

Of the dominant plants on plots supporting the highest densities of red-winged blackbirds, only *Poa pratensis* and *Symphoricarpos occidentalis* were present in far greater than average amount (Table 4). Other plants that seemed to indicate high quality grassland habitat for this species were *Andropogon scoparius*, *Stipa viridula*, *Rosa arkansana*, *R. woodsii*, and *Artemisia ludoviciana*.

Brewer's Blackbird

Our data showed that Brewer's blackbird was weakly attracted to moderately and heavily grazed tracts on the borolls and aridic ustolls. We found no literature references to the specific effects of grazing on density. Bendire (1895) noted that the species would nest on the ground in areas where it would not be trampled by cattle. Brewer's blackbirds probably favor grazed areas for foraging (Williams 1958; Orians and Horn 1969); brushy areas nearby are usually used for nesting (Belcher 1961; Stewart 1975; Salt and Salt 1976). *Artemisia tridentata*, a characteristic shrub on the ustic Aridisols, provides attractive nest sites (Peabody 1900; LaRivers 1944; Dumas 1950; Orians and Horn 1969) on these soils whereas *Symphoricarpos occidentalis* or *Rosa woodsii* probably serves this function on the borolls (Peabody 1900; Knapton 1979). Other trees or shrubs used in northern grasslands or parklands include *Salix* (Salt and Salt 1976; Knapton 1979), and *Corylus*, *Quercus*, and *Ribes* (Peabody 1900).

Artemisia tridentata was the dominant shrub and *Agropyron* spp. and *Koeleria pyramidata* were the dominant grasses occurring in above-average amounts on areas where the density of Brewer's blackbird was high. Other well represented shrubs were *Symphoricarpos occidentalis*, *Rosa woodsii*, and *Sarcobatus vermiculatus*.

Brown-headed Cowbird

The brown-headed cowbird reaches peak abundance in the northern plains (Friedmann 1929). We found peak densities on moderately grazed land on the typic ustolls of the southeastern portion of the northern Great Plains. Peak densities of western meadowlark also occurred where grazing was moderate in this area, possibly indicating a strong parasite-host relationship between these two species. Stewart (1975) reported that 77% of the recorded instances of cowbird parasitism in North Dakota was on nests of icterids and emberizids. Other known host species with fairly high densities in areas containing relatively high densities of cowbirds were lark bunting, chestnut-collared longspur, and grasshopper, Baird's, vesper, and clay-colored sparrows.

We found no consistent pattern of grazing effects on cowbird density among the soil groups. However, density was highest in only one of the six groups where grazing was light. Little has been reported about the effects of grazing on populations of brown-headed cowbird. Hahn (1941) observed that female cowbirds found host nests by watching for nest-building activities. Thus, removal of vegetation by grazing may enhance the cowbird's ability to locate nests of other birds.

Plant species associated with high densities of brown-headed cowbirds were *Poa pratensis* and *Artemisia ludoviciana*.

Lark Bunting

Heavily grazed plots on typic ustolls seemingly provided optimum breeding habitat for lark buntings on native grasslands; however, the effects of grazing varied greatly among the soil groups. On the cool, moist typic borolls, grazing apparently had little influence on population density, but on the aridic borolls and borollic Aridisols moderate or heavy grazing seemed to favor larger populations. On warm, dry soils, however, increased grazing intensity evidently resulted in much lower populations.

A. R. Dood (unpublished data) failed to find the species in lightly grazed Montana grasslands, though it was abundant in nearby sage grasslands. In contrast, Rand (1948), Finzel (1964), and Giezentanner (1970) found that in arid, shortgrass areas heavy grazing was detrimental to lark buntings. Shaded nest sites are a major habitat requirement of this species (Butterfield et al. 1969; Creighton 1971, Creighton and Baldwin 1974, Pleszczynska 1978). Low shrubs, cacti, forbs, or tall grasses generally serve this purpose (Cary 1902, Whittle 1922, Woolfolk 1945; Godfrey 1950, Benckeser 1957, Stewart 1975; Fairbanks et al. 1977).

Of the dominant plants on plots supporting large numbers of lark buntings, *Agropyron* spp., *Opuntia polyacantha*, and *Artemisia tridentata* exceeded average abundance (Table 4). Other plants indicative of heavily used habitat included *Agropyron spicatum*, *Aristida longiseta*, *Buchloe dactyloides*, *Calamovilfa longifolia*, *Stipa viridula*, and *Artemisia cana*.

Savannah Sparrow

Densities of savannah sparrows were highest on lightly and moderately grazed plots on typic borolls, and were much higher on grasslands developed over these cool, moist northern soils than on any other grasslands in the northern Great Plains.

Nesting savannah sparrows occupy habitat with dense ground cover (Tester and Marshall 1961; Lein 1968; Wiens 1969; Potter 1972). In the northern Great Plains grasslands, this habitat is provided by idle land or lightly grazed areas (Lincoln 1925; Rand 1948; Owens and Myres 1973; Stewart 1975; Karasiuk et al. 1977; Maher 1979; Kantrud 1981). Nest sites in arid western regions may be restricted to moist or shrubby areas (Silloway 1903; Sclater 1912; Saunders 1921; Godfrey 1950; Renaud and Renaud 1975; Salt and Salt 1976; South Dakota Ornithologists' Union 1978; Maher 1979).

Of the dominant plants on plots supporting highest savannah sparrow densities, *Koeleria pyramidata*, *Poa pratensis*, *Artemisia frigida*, and *A. ludoviciana* provided greater than average cover (Table 4). Other possible indicators of good habitat were *Carex eleocharis*, *Agropyron spicatum*, *Festuca idahoensis*, and *Stipa viridula*. Most breeding populations of savannah sparrow found in the mesic foothills grasslands, developed over typic borolls on the eastern slopes of the Rocky Mountains and around nearby isolated mountain ranges in Montana, were using habitat dominated by *Agropyron spicatum* and *Festuca idahoensis*.

Grasshopper Sparrow

The grasshopper sparrow, well distributed throughout the northern Great Plains, was densest on the typic ustolls and significantly denser on lightly grazed than heavily grazed plots. Moderately grazed areas supported intermediate densities of the birds within all soil groups. These findings are in agreement with most other observations in the northern Great Plains in North Dakota (Johnson 1972, 1973, 1974; Stewart 1975; Kantrud 1981), Alberta (Karasiuk et al. 1977), and South Dakota (Wiens 1973). Hopkins (1980) found higher densities on lightly grazed plots than on idle or moderately grazed plots in North Dakota. A population study by Wiens (1969) in Wisconsin indicated that preferred nesting cover was of intermediate height and density, and in Missouri Skinner (1975) found that moderate grazing may be required to ensure peak numbers.

Of the five commonest grasses on plots containing high densities of grasshopper sparrow, only *Agropyron* spp. was of more than average abundance (Table 4). Other plants apparently indicative of good habitat were *Poa pratensis* and *Stipa viridula*. Karasiuk et al. (1977) found that in Alberta the highest populations were on grasslands dominated by the genera *Agropyron*, *Bouteloua*, and *Stipa*.

Baird's Sparrow

Optimum habitat for Baird's sparrow probably consists of lightly grazed grasslands on typic borolls. The species may be restricted to depressions, low-lying grasslands, or moist draws in the more arid portions of its range (Allen 1874; Visher 1914; DuBois 1931; Harrold 1933; Godfrey 1950; Roy 1964). This restriction may hold primarily during dry years (Cartwright et al. 1937; Lane 1968) and be reversed during wet years (Salt and Salt 1976). Good nesting habitat contains litter and tall, rank grasses (Roberts 1932; Sibley and Pettingill 1955; Roy 1964; Lane 1968; Salt and Salt 1976). Stands of domestic grass may also be used (Godfrey 1950; Stewart 1975).

Heavy grazing usually has an adverse effect on the nesting habitat for Baird's sparrow, as indicated in the present work and by others (Youngworth 1944; Lane 1968; Maher 1972; Owens and Myres 1973), but Houston (1981) found this species on heavily grazed Saskatchewan grasslands. Moderate or light grazing is tolerated (Cartwright et al. 1937; Lokemoen and Duebbert 1974) but reduces nesting populations (Stewart 1975; Kantrud 1981). Idle land appears favorable (Todd 1947; Belcher 1961; Lane 1968; Renaud and Renaud 1975; Karasiuk et al. 1977; Knapton 1979). Although mowing reduces populations (Cartwright et al. 1937; Lane 1968; Owens and Myres 1973), land left idle during a breeding season after having been hayed during previous seasons may be heavily used (Kantrud 1981).

Dominant plants of greater than average abundance on plots containing peak numbers of Baird's sparrow were *Selaginella densa*, *Artemisia frigida*, *Koeleria pyramidata*, and *Stipa comata* (Table 4). Other plants providing above average cover on good habitat were *Carex eleocharis*, *Poa pratensis*, and *Stipa viridula*. In addition to many of these species, Stewart (1975) considered *Agropyron smithii*, *Andropogon scoparius*, and *Bouteloua gracilis* to be characteristic of the habitat of Baird's sparrow in North Dakota. In Saskatchewan the species preferred grasslands dominated by *Agropyron dasystachyum* and *Stipa spartea* (Lein 1968). In Alberta, greatest densities were associated with high cover values for *Selaginella densa*, *Carex obtusata*, *Festuca scabrella*, and *Stipa spartea* (Owens and Myres 1973).

Vesper Sparrow

The vesper sparrow is common on all soils except the typic and aridic ustolls. Populations were somewhat higher on soils where shrubs (primarily *Artemisia tridentata*) were common. The vesper sparrow reached nearly equal peak densities where grazing was moderate on the borollic Aridisols and light in the ustic Aridisols. Heavy grazing did not depress breeding populations very much.

In shortgrass, grazing usually resulted in reduced populations (Rand 1948; Godfrey 1950; Belcher 1961), although Houston (1981) found this sparrow associated with longspurs on heavily grazed shortgrass prairie. In shrubsteppe habitat in the northern Great Plains, however, heavily grazed areas were well accepted (Scott et al. 1964). Olsen (1974) reported an increase in populations in Great Basin sagebrush grassland when grazing was deferred from spring to fall. A wide range of sagebrush canopy cover was tolerated by vesper sparrows in an area of Montana where this species composed 36% of the breeding bird population (Feist 1968). Grinnell and Miller (1944) stressed the need of vesper sparrows for much open or sparsely vegetated ground in California sagebrush. Braun et al. (1976) termed the species a "near obligate" to sagebrush, but the western race apparently prefers grassland (Dumas 1950; Johnsgard and Rickard 1957). Monson (1941) found slightly higher populations in moderately grazed than in overgrazed pastures in Arizona shrub grasslands where *Atriplex canescens* was the dominant shrub. In West Virginia, successful nests were in habitats where vegetation density and litter depth were greater (and amounts of bare soil were less) than in habitat with unsuccessful nests (Wray and Whitmore 1979).

Dominant plants occurring in above-average abundance on plots supporting maximum numbers of vesper sparrows were *Agropyron* spp., *Koeleria pyramidata*, *Artemisia frigida*, and *A. tridentata* (Table 4). Other plants seemingly indicative of good habitat included (in decreasing order of abundance) *Agropyron spicatum*, *Stipa viridula*, *Poa sandbergii*, *Opuntia polyacantha*, and *Artemisia cana*.

Clay-colored Sparrow

The clay-colored sparrow was an important species only on the typic borolls. On these soils densities were significantly higher where grazing was light than where it was either moderate or heavy. References to the effects of grazing on this species (Johnson 1972, 1973, 1974; Owens and Myres 1973; Knapton 1978; Kantrud 1981) fully confirm these observations.

There are numerous references to the attractiveness of *Symphoricarpos* for nesting by the clay-colored sparrow in the northern prairies (Kantrud 1981). Knapton (1978) postulated that the thinning of *Symphoricarpos* nesting cover by grazing increased nest visibility and that this greater visibility resulted in increased parasitism by the brown-headed cowbird. Other genera of shrubs or small trees used for nesting include *Salix* (Owens and Myres 1973), *Corylus* (Roberts 1932), *Celtis* (Peabody 1899), *Potentilla* (Saunders 1921), *Prunus* (Renaud and Renaud 1975), *Rosa* (Peabody 1899; Roy 1964; Salt 1966; Renaud and Renaud 1975), *Elaeagnus* (Bailey 1915*b*; Fairfield 1962; Root 1968; Renaud and Renaud 1975), *Shepherdia* (Saunders 1921), *Cornus* (Salt and Salt 1976), and *Artemisia* (Silloway 1903; Saunders 1921). Thompson (1890) stated that clay-colored sparrows also nested on the ground.

During our study *Symphoricarpos occidentalis* occurred with 100% frequency, and mean cover value five times greater than average, on plots supporting high densities of clay-colored sparrows. Other shrubs in greater than average abundance were *Rosa woodsii* and *Amorpha canescens*. Cover values for *Koeleria pyramidata*, *Poa pratensis*, and *Artemisia ludoviciana* were also well above average.

Brewer's Sparrow

Lightly grazed tracts in the *Artemisia tridentata*-dominated ustic Aridisols supported by far the highest densities of Brewer's sparrow. This observation is in agreement with Taylor (1912) and Walcheck (1970), who found densities of Brewer's sparrow directly related to canopy coverage of *A. tridentata*. Reynolds and Trost (1980) recorded more Brewer's sparrow nests in ungrazed than in grazed *A. tridentata* habitat in

Idaho. Olsen (1974) noted a marked increase in nests of Brewer's sparrow in Idaho sagebrush grasslands after grazing was deferred from spring to fall, and suggested that the increase resulted from enhancement of the attractiveness of sparse sagebrush by taller grasses.

In most other soil groups, numbers of Brewer's sparrow tended to be greater where grazing was moderate. In all soil groups density was lowest where grazing was heavy. This differs from Monson (1941) who found greater numbers of Brewer's sparrow on overgrazed areas. However, other factors such as topography may influence territory size of Brewer's sparrow (Scott et al. 1964).

Brewer's sparrows have been associated with *Atriplex canescens* (Monson 1941), *Artemisia cana* (Thompson and Sullivan 1979), *A. dracunculus* and *A. ludoviciana* (Baldwin 1956), and the genera *Sarcobatus* (South Dakota Ornithologists Union 1978), *Ribes* (Bailey and Niedrach 1965), *Amelanchier* (Johnsgard and Rickard 1957), *Cercocarpus* (Bailey and Niedrach 1965), *Crataegus* (Johnsgard and Rickard 1957), *Prunus* (Johnsgard and Rickard 1957), *Geranium* (McGee 1976), *Shepherdia* (Saunders 1914), *Achillea* (McGee 1976), and *Chrysothamnus* (Johnsgard 1955; Baldwin 1956; Fairbanks et al. 1977). Brewer's sparrows evidently do not require shrubs if bunchgrasses or forbs of suitable height are present (Wing 1949; McGee 1976).

Artemisia tridentata was the commonest plant on plots supporting high densities of Brewer's sparrow. Other shrubs or half shrubs with more than average cover value were *Atriplex nuttallii*, *Sarcobatus vermiculatus*, and *Artemisia cana*. *Agropyron* spp., *Poa sandbergii*, and *Opuntia polyacantha* also provided well above average cover on these plots.

McCown's Longspur

Density of McCown's longspur was greatest where grazing was heavy on the aridic borolls of northern Montana. Southern populations nesting on the aridic ustolls of southeastern Wyoming and northeastern Colorado probably preferred moderately grazed areas.

Near the turn of the century, populations of McCown's longspur were greatly reduced in parts of Saskatchewan, large areas of the Dakotas, and smaller portions of Minnesota for unknown reasons. Fire, subtle climatic changes, and changes in grazing regimes have been suggested (Krause 1968; Houston 1981). The preference of the northern population for heavily grazed areas agrees with observations by Ferry (1910), DuBois (1935), and Maher (1972, 1979), but not with those of Houston (1981). Felske (1971) attributed preference for short vegetation by McCown's longspur to the warmth and dryness that are imparted to the soil from overgrazing, and the resulting readily available supply of prey (orthopterans) during the peak nesting period. Southern birds evidently are more variable in their response to grazing. Ryder (1980) indicated that heavily grazed areas in Colorado were preferred over lightly grazed areas. Giezentanner (1970) recorded McCown's longspur on both heavily and lightly grazed plots in Colorado but not on moderately grazed areas. During one year of Giezentanner's study, population densities were twice as high on the heavily grazed as on the lightly grazed plots, but in another year they were identical. Areas grazed only in winter were unused, regardless of grazing intensity, presumably because of the presence of tall vegetation (Ryder 1980). Creighton and Baldwin (1974) found Colorado birds to be associated with large amounts of bare soil on hilltops and rises and with *Bouteloua gracilis*, *Buchloe dactyloides*, and *Opuntia polyacantha*. Finzel (1964) recorded uniformly higher densities on the grazed *Bouteloua-Buchloe* grasslands than on grasslands dominated by the taller *Stipa-Bouteloua* association in southeastern Wyoming.

Dominant plants contributing above average cover values on plots containing upper tercile densities of McCown's longspur were *Selaginella densa*, *Bouteloua gracilis*, *Koeleria pyramidata*, *Stipa comata*, and *Artemisia frigida* (Table 4); other abundant plants were *Poa sandbergii* and *Ceratoides lanata*. In areas of Wyoming where *Artemisia tridentata* form the general vegetation, isolated breeding populations of McCown's longspur are found on hilltops or mesas where the much shorter *Artemisia pedatifida* is a dominant plant.

Chestnut-collared Longspur

The most abundant breeding bird on the northern Great Plains grasslands is the chestnut-collared longspur. Typic soils supported the highest populations; heavy grazing of these soils evidently provided optimum nesting habitat. On more arid soils, densities were generally lower. Moderate or light grazing may be required to maintain high populations.

In more arid regions of the Great Plains the chestnut-collared longspur may become mostly restricted to, or reach greatest abundance in, lower, moister areas (Allen 1874; Saunders 1921; DuBois 1935, 1937; Bailey and Niedrach 1938; Rand 1948). In regions of greatest concentration, however, the species is normally abundant in most uplands. In arid areas such as northeastern Colorado, densities may be highest in moderately or even lightly grazed pastures (Giezentanner 1970; Ryder and Strong 1971). Wiens (1973) failed to find the species in grazed areas in southwestern South Dakota, but grazing is probably required to provide vegetation short enough to attract breeding populations in areas of Alberta dominated by the taller fescue bunchgrasses (Owens and Myres 1973) and in the grasslands of southwestern Saskatchewan (Houston 1981). On the moister, eastern edge of its range, the chestnut-collared longspur may be restricted to the highest and driest sites available (Cantwell 1889; Currie 1892; Roberts 1932). In moister areas, heavy grazing is preferred (Harris 1944; Belcher 1961; Fairfield 1962; Roy 1964; Kantrud 1981).

Nesting habitats of chestnut-collared longspurs have also been related to the plant community, which supports our findings on the effects of soil moisture and grazing intensity. Stewart (1975) listed several midgrasses and shortgrasses as characteristic of grazed mixed-grass habitat for the chestnut-collared longspur in North Dakota. For ungrazed habitat, only the shortgrasses were listed. In much drier Colorado habitat, this longspur was closely associated with grazed midgrasses and sedges; most nests were domed over with *Aristida longiseta* or various species of *Agropyron* (Creighton and Baldwin 1974).

In areas of high density of chestnut-collared longspurs, plants with above average cover value were *Selaginella densa*, *Bouteloua gracilis*, *Koeleria pyramidata*, and *Stipa comata*. Thompson and Sullivan (1979) found higher populations on Montana grasslands dominated by *Bouteloua gracilis* and *Stipa comata* than on those dominated by *B. gracilis* and *Agropyron smithii*.

Relation of Birds to Soils

The chestnut-collared longspur was by far the commonest bird on the study plots, followed by the horned lark and western meadowlark (Table 1). These three species accounted for over 60% of the total indicated pairs. The two rarest grassland birds were the mountain plover and ferruginous hawk. Of the 29 species studied, 15 occurred on all of the soils. Twenty-eight were observed on the typic borolls, but only 21 and 22 species, respectively, were seen on typic and aridic ustolls.

The major soils used for stratification of sample plots during this study were differentiated primarily on the basis of temperature, moisture, and organic matter content. These factors may account for some of the wide variation we found in use of the strata by breeding birds. In the analysis used to construct Table 1, the effect of soils was conditional on grazing intensity. Under this condition, species richness was not significantly affected by interaction between the two environmental variables (soils and grazing intensity) nor did the interaction significantly affect the densities for 15 of the 29 species studied. Of the remaining 14 species, either significant interaction occurred between the variables (9 species) or no significant test results were obtained (5 species).

Average total bird density and species richness were only slightly higher on Mollisols than on Aridisols and only slightly higher on typic than on aridic soils, indicating that organic matter content and soil moisture probably are not highly important to grassland birds. The strongest difference in species richness appeared to be related to soil temperature, especially among the aridic Mollisols and the Aridisols.

Species use of the various soil strata varied greatly. On the cooler borolls, significantly higher densities of seven species were found under typic than aridic moisture conditions: upland sandpiper, common yellowthroat, western meadowlark, red-winged blackbird, savannah sparrow, clay-colored sparrow, and chestnut-collared longspur. Conversely, the aridic borolls supported higher densities of Brewer's sparrow and McCown's longspur. Similarly, among the warmer ustolls, significantly higher densities of four species were found under typic than aridic moisture regimes: upland sandpiper, western meadowlark, red-winged blackbird, and chestnut-collared longspur. McCown's longspur reached far greater density where soils were aridic.

Densities of several other common species varied greatly among the Mollisols, although differences were not significant due to variability introduced by grazing effects. These included horned lark, which apparently preferred aridic over typic moisture conditions; Baird's sparrow, which showed strong affinity for the borolls; and bobolink, brown-headed cowbird, lark bunting, and grasshopper sparrow, which attained much higher concentrations on the typic ustolls.

On the Aridisols, significantly greater densities of western meadowlark and chestnut-collared longspur were found on the borollic soils, whereas Brewer's sparrows were highly concentrated on ustic soils. Markedly higher densities of horned lark, lark bunting, and grasshopper sparrow were found on the borollic soils and noticeably higher numbers of sage thrasher occurred on the ustic group, but the differences in density were not significant due to grazing interactions.

Response of Birds to Grazing

In the analysis of grazing effects across all soils, interaction between both input variables was considered. This model showed significantly higher species richness on moderately than on heavily grazed plots (Table 2) and fairly uniform densities for total birds under the three grazing intensities.

Numbers of horned lark, western meadowlark, lark bunting, and chestnut-collared longspur accounted for 65-75% of the total bird population for the entire study area, regardless of grazing intensity. The responses of killdeer and western meadowlark to grazing intensity were positive and negative, respectively.

The effects of grazing were also analyzed among soils (Table 2). In these models, significant relations to grazing intensity were found for total bird density and for the density of five species on soils in which their peak densities occurred.

Total bird density was fairly uniform under the three grazing intensities. An exception was on the borollic Aridisols, which supported significantly higher densities of breeding birds where grazing was heavy. The area occupied by these soils supported exceptionally high densities of horned lark. Species richness was highest where grazing was light or moderate on the Mollisols, but always highest where grazing was moderate in the Aridisols.

Horned lark populations showed a significantly positive response to grazing within each of the six soils, but differences in density among grazing regimes were not significant for the study as a whole. Common yellowthroat, bobolink, and grasshopper, Baird's, and Brewer's sparrows showed significant negative response to grazing on the soil on which they were most dense. In addition, on the typic borolls the densities of burrowing owls and red-winged blackbirds were greater on heavily and lightly grazed areas, respectively.

Several common species responded differently to grazing. Chestnut-collared longspurs apparently reached peak densities where there was heavy grazing on the typic soils, moderate grazing on the aridic borolls, and light grazing on the aridic ustolls. The density of McCown's longspur was highest where there was heavy grazing on the aridic borolls and borollic Aridisols and moderate grazing on the aridic ustolls and ustic Aridisols. Lark bunting density seemingly peaked where grazing was heavy on the typic ustolls, but was significantly lower on heavily than lightly grazed plots on the aridic ustolls.

Other species may have preferred certain grazing levels, as follows: lightly grazed, long-billed curlew and clay-colored sparrow; lightly or moderately grazed, marsh hawk, sharp-tailed grouse, Sprague's pipit, savannah sparrow, and vesper sparrow; moderately or heavily grazed, mourning dove and Brewer's blackbird; and heavily grazed, mountain plover.

Relation of Vegetation to Soils and Grazing

The composite species list of the dominant plants on the study plots (Table 3), which comprises the species with mean areal cover >1% in one or more of the combinations of soil and grazing intensity, contains only 22 species. (We could not differentiate *Agropyron dasystachyum* from *A. smithii* by their vegetative characteristics so these two species were combined.) This small number attests to the relatively simple floristics of the northern Great Plains grasslands. Best represented were grasses (12 species), followed by three forbs (*Opuntia polyacantha*, *Artemisia frigida*, *A. ludoviciana*), two sedges (*Carex eleocharis*, *C. filifolia*), two half-shrubs (*Atriplex nuttallii*, *Ceratoides lanata*), two shrubs (*Artemisia cana*, *A. tridentata*), and a selaginella (*Selaginella densa*). *Poa pratensis* is an intro-

Table 5. *Mean cover values*[a] *of plants associated with upper tercile*[b] *densities of breeding grassland birds. Bird species include those for which 10 or more upper tercile values were obtained. Numbers above plant species names indicate abundance rank and those in parentheses below names show mean cover values for entire study area.*

Species and (in parentheses) number of plots in which species was within upper tercile	1 *Bouteloua gracilis* (2.5)	2 *Agropyron* spp. (2.4)	3 *Stipa comata* (1.9)	4 *Carex filifolia* (1.7)	5 *Koeleria pyramidata* (1.6)	6 *Artemisia frigida* (1.1)	8 *Opuntia polyacantha* (0.9)	10 *Artemisia tridentata* (0.8)	13 *Selaginella densa* (0.6)	14 *Artemisia ludoviciana* (0.6)	15 *Poa pratensis* (0.6)
Marsh hawk (21)	2.0	2.0	2.0		1.6	1.1			1.2		
Killdeer (47)	2.9	2.6	1.7	1.7	1.4	1.3					
Long-billed curlew (10)	2.7	1.0	1.1		1.4	1.4			1.7		
Upland sandpiper (33)	2.6	2.6	1.5	1.4		1.1				0.9	1.3
Mourning dove (39)	2.7	2.4	1.6	1.8	1.2	0.8	1.0				
Common nighthawk (17)	3.0	2.1	1.4		1.4		1.2		1.1		
Horned lark (160)	3.0	2.3	2.0	1.6	1.4	1.2	1.2				
Sage thrasher (15)	1.9	2.8		2.0	1.6	0.8	1.5	1.1			
Sprague's pipit (29)	1.8	1.9	2.3	1.5	2.2	1.3			1.7	0.9	
Western meadowlark (186)	2.6	2.8	1.9	1.7	1.5	1.1	0.9	1.0			
Red-winged blackbird (13)	2.1	2.2	1.5		1.4	1.1					1.9
Brewer's blackbird (28)	2.2	2.6	1.6	1.6	2.1	1.2	1.0	1.9			
Brown-headed cowbird (48)	2.4	2.3	1.5		1.5	1.1				1.0	1.5
Lark bunting (91)	2.6	2.8	1.9	1.6	1.4	0.9	1.2	1.2			
Savannah sparrow (16)	2.0	1.8	1.9		1.9	1.3				1.2	2.1
Grasshopper sparrow (77)	2.3	2.8	1.9	1.5	1.5	0.9					
Baird's sparrow (38)	1.9	1.9	2.2	1.7	2.6	1.3			1.5		
Vesper sparrow (84)	2.5	2.9	1.9	1.8	2.0	1.3		2.0			
Clay-colored sparrow (21)		1.4	2.0	1.6	1.9	1.1				1.0	2.0
Brewer's sparrow (67)	2.4	2.7	1.5	1.5		1.0	1.6	2.9			
McCown's longspur (39)	2.7	2.3	2.4	1.8	1.8	1.5	0.8		0.8		
Chestnut-collared longspur (106)	2.7	2.4	2.2	1.6	1.9	1.3	0.8		1.0		

[a] Areal cover classes (and range of cover in percent) were as follows: 1 (0–1), 2 (1–10), 3 (10–25), 4 (25–50), 5 (50–75), 6 (75–90), 7 (90–100).

[b] Terciles are points dividing the distribution of values for observed species density (pairs/km^2 $\times$ 10^4) among the sample units into thirds.

Grasses and sedges include those with the five highest mean cover values on plots supporting highest (upper tercile) densities of each bird species; all other types of plants included if among the 10 highest in cover.

[d] The following five plants, not listed in the table, are summarized here in the following order: name, abundance rank (and mean cover value), bird species with their upper tercile densities. *Poa sandbergii*, 7 (1.0), sage thrasher 1.9 and Brewer's sparrow 1.6. *Carex eleocharis*, 11 (0.8), marsh hawk 1.6 and long-billed curlew 1.0. *Buchloe dactyloides*, 12 (0.7), common nighthawk 1.4. *Chrysopsis villosa* (hairy goldenaster), 16 (0.5), long-billed curlew 0.9. *Symphoricarpos occidentalis* (western snowberry), 24 (0.4), red-winged blackbird 1.3 and clay-colored sparrow 2.0.

duced plant. The warmer soils, typic and aridic ustolls and ustic Aridisols, tended to have the simplest vegetation (only 8–11 dominant species). The typic borolls occur in widely disjunct areas and the plants listed in Table 3 best represent the vegetation found on the larger, eastern unit of this soil (Fig. 3). In the western unit, *Agropyron spicatum* and *Festuca idahoensis* are important floral components.

Among the Mollisols, species richness seemingly was related primarily to soil temperature. Borolls averaged 60 species per plot compared with only 43 for ustolls, and borollic and ustic Aridisols averaged 44 and 46 species per plot, respectively.

The most abundant plants, *Carex filifolia*, *Agropyron* spp., *Bouteloua gracilis*, and *Stipa comata* were well represented on all soils. *Koeleria pyramidata* and *Stipa viridula* were also well represented, being unimportant in only a single soil. Seven species were important in only one soil: *Atriplex nuttallii*, *Ceratoides lanata*, *Artemisia ludoviciana*, *Agropyron spicatum*, *Andropogon scoparius*, *Aristida longiseta*, and *Calamovilfa longifolia*.

Although our subjective estimates of grazing intensity were based on current conditions, our findings agree well with the many published studies of long-term plant response to intensity of grazing by livestock in the northern Great Plains. Species richness tended to decrease as grazing intensity increased except on the typic Mollisols. Species showing positive response to grazing included *Selaginella densa*, *Opuntia polyacantha*, *Bouteloua gracilis*, and *Buchloe dactyloides*. Greatest single-species dominance was by *Bouteloua gracilis* on heavily grazed tracts in the borollic Aridisols. Six species showed mixed response or rather uniform cover values among soils under the three grazing regimes: *Artemisia frigida*, *A. ludoviciana*, *A. tridentata*, *Carex eleocharis*, *C. filifolia*, and *Aristida longiseta*.

Estimates of the average height of vegetation and the percentage of bare soil on a sample of the study plots are presented in Table 4. As expected, increased grazing intensity resulted in decreased vegetative height on all soils. Tallest vegetation occurred on the moister typic soils and on the shrubby ustic Aridisols, and shortest vegetation was recorded on aridic soils and the borollic Aridisols.

The percentage of bare soil bore a positive relation to grazing intensity on all soils. Minimum exposure of bare soil occurred under light grazing on typic soils and maximum exposure was recorded on the heavily grazed aridic borolls and ustic Aridisols.

Relation of Birds to Plants

In Table 5 the plants are ranked by mean cover value for the entire study area, for comparison with values for the plots supporting high densities of each bird species. Associations of plants with birds must be interpreted carefully because they may merely reflect the general abundance of dominant plants within the distributional area of the bird species. Special caution must be used for the larger, wide-ranging nonpasserines because they may require different habitats for feeding, nesting, brood-rearing, or other activities conducted during the breeding period.

All five of the most important grasses and sedges on the study area had noticeably greater-than-average cover values on plots associated with high densities of at least one of the bird species listed. The more conspicuous high-cover value associations included (1) *Agropyron* spp. with killdeer, upland sandpiper, sage thrasher, western meadowlark, Brewer's blackbird, lark bunting, and grasshopper, vesper, and Brewer's sparrows; (2) *Koeleria pyramidata* with Sprague's pipit, Brewer's blackbird, the two longspurs, and savannah, Baird's, vesper, and clay-colored sparrows; (3) *Bouteloua gracilis* with killdeer, long-billed curlew, mourning dove, common nighthawk, horned lark, and the two longspurs; (4) *Stipa comata* with Sprague's pipit, Baird's sparrow, and the two longspurs; and (5) *Carex filifolia* with sage thrasher.

Among the less common grasses and sedges, *Poa pratensis* was associated with the most bird species. The cover value of this introduced grass, which ranked only 15th in overall abundance on the study area, was high on plots supporting high densities of upland sandpiper, red-winged blackbird, brown-headed cowbird, savannah sparrow, and clay-colored sparrow. Other associations of grasses and sedges with apparently more attractive bird habitat included *P. sandbergii* with sage thrasher and Brewer's sparrow, *Carex eleocharis* with marsh hawk and long-billed curlew, and *Buchloe dactyloides* with common nighthawk.

Among the forbs, *Artemisia frigida* occurred in greater-than-average abundance on plots attractive to killdeer, long-billed curlew, Sprague's pipit, the two longspurs, and savannah, Baird's, and vesper sparrows. *Opuntia polyacantha* evidently was indicative of better-than-average habitat for common nighthawk, horned lark, sage thrasher, lark bunting, and Brewer's sparrow.

All other forbs and shrubs showed greater-than-average abundance in better habitat for the bird species listed. Especially noticeable was increased abundance of *Artemisia tridentata* in prime habitat for sage thrasher, Brewer's blackbird, and vesper and Brewer's sparrows; of *Selaginella densa* for long-billed curlew, Sprague's pipit, and Baird's sparrow; and of *Symphoricarpos occidentalis* for red-winged blackbird and clay-colored sparrow.

Effects of Soils and Grazing on Bird Communities

Climate and Soils

Attempts to relate climatic factors to bird species richness and diversity have met with limited success because of the complex relations between climate, topography, elevation, soils, and the vegetative substrate of birds. We can only speculate as to the effects of climate on birds through the characteristics of the soils (Fig. 4) we used to stratify the sample plots. Although the genesis of these soils is directly related to climatic factors, texture and other soil factors probably less directly related to climate may also influence the grassland fauna (Lohoefener and Ely 1978).

A general decrease in bird species richness to the south and west in the northern Great Plains shown by Cook (1969) is also evident in our data (Table 1). This decrease may follow similarly oriented gradients of increased soil temperature and decreased soil moisture in this area. It is difficult to envision how this decrease can be attributed to changes in vegetative height because vegetation on the warmest, driest soil was taller than on some of the cooler or moister soils (Table 4). However, the decrease may possibly be related to the general decrease in vegetative cover on the warmer, drier soils (Table 4).

Schall and Pianka (1978) found that major abiotic variables had little effect on avian species density throughout the northern Great Plains. However, in the USSR and Argentina, Terent'ev (1963) and Rabinovich and Rapoport (1975) reported species richness to be more closely related to temperature than to rainfall, and Kaiser et al. (1972), who analyzed variations in similarity and species richness of passerine and non-passerine birds across Canada, indicated that the resulting patterns coincided better with a simple temperature-sunshine factor than with boundaries of major continental air masses.

During our study, increased soil temperature probably had the greatest negative influence on species richness in the northern Great Plains as evidenced by the consistently high values among the cool borolls and borollic type soils.

Studies of avian thermoregulation (Ricklefs and Hainsworth 1969; Creighton 1971; Trost 1972; Graul 1975; Austin 1976; Pleszczynska 1978) have indicated that options for use of microhabitats to relieve heat stress may be more limited in grasslands than in desert. Herbage removal by grazing probably would result in further decreases in microhabitat options.

Although Wiens (1973, 1974) found no close relations between avian species richness or diversity and either the mean annual precipitation or the long-term predictability and variability of precipitation across a variety of North American grassland and shrubsteppe types, he suggested that, compared with tallgrass prairie, the greater climatic instability found in areas of shortgrass prairie would place greater restrictions on the number of bird species that could successfully breed there. Other investigators (Kikkawa 1968; Rotenberry 1978; Kantrud 1981) have shown more distinct relations between bird distributions and moisture gradients. Our data indicated that soil moisture was an important factor only in the warm Mollisols. Species richness did not differ significantly between typic and aridic borolls (Table 1). Borollic Aridisols were not significantly lower in species richness than aridic borolls, indicating that organic matter content of grassland soils was also not especially important. Ustic Aridisols supported a richer avifauna than aridic ustolls, probably because of the greater habitat heterogeneity in grasslands containing large amounts of *Artemisia* spp. and other shrubs, rather than to features related to lower organic matter content. The presence of a shrub layer also increased species richness in desert grassland (Meents 1979).

Grazing

Many important vegetative characteristics may be changed by grazing, and these in turn alter surface water runoff, soil moisture, temperature, soil erosion, and other abiotic factors. Interactions are greatly complicated by variations in climate, topography, and soils. (For a review of many of the effects of herbage removal on grassland and shrubsteppe ecosystems, see Ellison [1960] and Humphrey [1962].) The changes wrought by livestock and other grazing animals affect the rest of the consumer component, including birds.

The primary effect of grazing on the breeding bird community in grasslands may be that resulting from physical alterations to the vegetative substrate used for nesting (Monson 1941; Beecher 1942; Overmire 1963; Creighton and Baldwin 1974; Bove 1977). Relations between birds and specific plant dominants or groups of dominants are usually weak, but many studies have shown strong correlations of birds with plant life forms. Morphological differences between species within a single plant family may greatly influence use by both passerine and non-passerine birds (Dumas 1950).

Cody (1968, 1974) concluded that grassland birds coexist by virtue of differences in habitat preference and feeding behavior and, in very tall vegetation, by differences in feeding height. Shortgrass prairie allowed for the greatest variety of feeding behavior and tallgrass permitted an increase in vertical foraging range. In mixed prairie, neither of these factors operated and the birds selected patches of habitat of differing heights. However, the structure of the various grassland types may be drastically altered by grazing. Studies of the Grassland Biome under the International Biological Program indicated that grazing intensity and grazing season can have local effects on avian species composition that obscure those due to regional differences in grassland type (Wiens 1973), and that the effects of grazing vary from area to area (Wiens and Dyer 1975; Ryder 1980).

Grazing by domestic livestock can rapidly alter the use of grasslands by breeding birds through changes in height and density of the vegetation. Over longer periods, grazing may also determine the vegetative life forms that are available to the breeding population through basic changes in plant species composition. Various investigations of passerine birds in grasslands have related the effects of grazing on food (Smith 1940; Maher 1973; Creighton and Baldwin 1974), predation (Hyde 1939*a*; Potter 1974), clutch size (Graul 1973), and nest parasitism (Knapton 1978).

In five of the six major soils, and for the area as a whole, grazing intensity did not greatly affect total bird density (Table 2). In the single soil group where heavy grazing resulted in significantly higher total bird density (borollic Aridisols), the increase was due primarily to extremely high populations of the horned lark and, to a lesser extent, greater numbers of longspurs.

Several studies of the relation between total density of breeding birds and grazing have been conducted in northern Great Plains grasslands. However, in most of these studies only small numbers of plots were censused and the plots were usually small. Studies conducted in areas dominated primarily by the typic borolls include those of Johnson (1972, 1973, 1974), Hopkins (1980), and Kantrud (1981) in North Dakota. Results of the studies by Johnson and Hopkins were similar to ours in that there were no great differences in total bird density among grazing regimes. In Kantrud's study, total bird density tended to increase with grazing intensity, mostly because populations of horned lark and chestnut-collared longspur increased.

Studies by Maher (1973), Owens and Myres (1973), and Karasiuk et al. (1977) related total bird density to the effects of grazing in Canadian mixed-grass prairie (Smith 1977). Soils in these areas are similar to the aridic borolls of northern Montana (Canada Surveys and Mapping Branch 1974). In the first two studies, grazed plots were compared with ungrazed plots. Maher's (1973) investigation showed greatest bird numbers on the grazed plots; however, Owens and Myres (1973) found the opposite. Karasiuk et al. (1977) found almost no difference in total bird density between lightly and heavily grazed areas. Our findings for the aridic borolls are closest to those of Maher (1973). In both studies, grazing evidently resulted in increases in numbers of horned lark and longspurs that were greater than the decreases in populations of other species that are probably more sensitive to grazing.

No comparable information is available for the borollic Aridisols of southeastern Montana and northwestern South Dakota and the typic ustolls of eastern South Dakota (Fig. 2). We found significantly higher total bird density in heavily grazed borollic Aridisols but only (nonsignificant) slightly higher densities on heavily grazed typic ustolls (Table 2). Increases in populations of the longspurs and horned lark kept total bird density high on the heavily grazed areas. In contrast, in a study area at the extreme eastern edge of the ustic Aridisols in southwestern South Dakota, Wiens (1973) found total bird density more than twice as high in idle or undisturbed areas than in grazed tracts. We noted only slight decreases in total bird density on these soils on moderately and heavily grazed plots. Here the increased density of horned lark compensated for reduced densities of the large number of species that evidently require greater amounts of vegetative cover. Reynolds and Trost (1980) found that grazing did not significantly alter total bird density in the *Artemisia*-dominated shrubsteppe of Idaho. Soils in that area are similar to the ustic Aridisols of the northern Great Plains (U.S. Geological Survey 1970).

Studies summarized by Ryder (1980), conducted in the shortgrass plains of northeastern Colorado, yielded results similar to ours for the aridic ustolls. Both studies indicated slightly higher total bird density on lightly grazed plots.

Species richness was significantly reduced by heavy grazing in the northern Great Plains (Table 2). Reductions were most marked on typic borolls and borollic Aridisols. In North Dakota, where most soils are classed as typic borolls (A. R. Aandahl, map), Kantrud (1981) also showed a progressive decrease in richness as grazing intensity increased. Other studies of the effects of grazing on species diversity and richness in the northern Great Plains grasslands have generally been hampered by the small sizes of samples and plots, but most are nevertheless in agreement with our findings.

Wiens and Dyer (1975) found greater species diversity on ungrazed than on grazed sites at Cottonwood, South Dakota, and the Pawnee National Grasslands, Colorado. Soils in these two respective areas are dominated by ustic Aridisols and aridic ustolls. Smith (1977) found species diversity higher under ungrazed than grazed conditions on a Matador, Saskatchewan, study area although an equal number of species was present under both conditions. Earlier, however, Maher and Felske (1970) reported that numbers of breeding species on this area decreased considerably with increases in grazing intensity.

Species diversity was also reduced by grazing in Alberta grasslands (Owens and Myres 1973; Karasiuk et al. 1977). Soils in these Canadian areas are similar to the aridic borolls of northern Montana. Hopkins (1980) recorded six species on moderately grazed areas compared with five on lightly grazed areas in North Dakota, but Johnson (1972, 1973, 1974) found a slightly greater number of species on heavily grazed than on lightly to moderately grazed tracts in North Dakota. Soils in these areas are mostly typic borolls.

We made only rough visual estimates of average vegetative height and the percentage of bare soil exposed on a sample of the study plots (Table 4), and we can only speculate as to the effects of these two variables on birds. Accurate assessment of the effects of these factors on birds probably would be impossible even with long-term studies of plots with known grazing histories and of plots in idle or undisturbed conditions to be used for controls, because a myriad of other structural characteristics of variously grazed grassland vegetation, many of which are intercorrelated themselves, are correlated with the abundance of many grassland birds (Rotenberry and Wiens 1980).

Average vegetative height is especially difficult to visually estimate or mechanically measure except on small, undisturbed plots, and grazing adds further complications. Although grazing by domestic livestock generally decreased average vegetative height and increased the exposure of bare soil, we occasionally encountered lightly grazed plots where height of the vegetation seemed to be decreased because of the shading effect of large amounts of litter. Conversely, taller growths of unpalatable shrubs or perennial grasses were seen on some heavily grazed plots; this probably occurred as these plants were released from competition with more palatable species for water or nutrients. In addition, exposure of bare soil through grazing or trampling sometimes resulted in an increase in tall, weedy annual plants. These plants formed a sparse canopy over the shorter grasses and gave the vegetation a two-layered aspect. Plots in this condition attracted, in addition to the suite of birds typical of short, heavily grazed grasslands, species such as lark bunting and grasshopper sparrow, which usually reached greatest abundance in lightly or moderately grazed grasslands; these species probably would not have been present had it not been for the canopy of annual plants.

Nevertheless, the relations between bird species richness and density and the physical alterations to the height and cover of vegetation due to grazing were probably similar to those found for grazing in general (Table 2) on the soils we studied: increased richness was associated with plots in which the height of the vegetation was not appreciably reduced and the percentage of bare soil not greatly increased by heavy grazing. Reduced plant height and increased soil exposure seemingly was not related to total bird density except where density was greatly increased, primarily by large numbers of horned lark, on heavily grazed borollic Aridisols.

Comparisons of bird density (Table 2) and average heights of the vegetation among soils and grazing intensities (Table 4) indicate that some species may select vegetation of different heights on different soils. For example, high densities of chestnut-collared longspur probably occurred in vegetation averaging about 17–18 cm tall on the relatively moist typic soils, but in the drier aridic borolls and ustolls, high densities were probably associated with vegetation in the 20–23 cm range. Similarly, McCown's longspur probably reached high densities in the 5–8 cm vegetation in the relatively cool, dry aridic borolls and borollic Aridisols, but seemingly preferred vegetation in the 10–20 cm range in the warm, dry aridic ustolls and ustic Aridisols.

Agricultural and livestock producing activities have had severe impacts on grassland birds in the northern Great Plains, especially in the northern and eastern portions of the area where most of the highly fertile and productive typic borolls and ustolls occur. Most land in areas containing these soils is now intensively farmed or heavily grazed and only remnants of native grassland remain. We recommend that protection be given to tracts of unplowed native grassland representative of the various soil types found throughout the northern Great Plains. On protected areas, management by grazing or burning or a combination of both practices should be applied to enhance the survival of some of the less common grassland birds. As suggested by Graul (1980), grassland management practices based on habitat requirements of the stenotopic species would benefit many of the eurytopic species as well.

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References

Ailes, I. W. 1976. Ecology of the upland sandpiper in central Wisconsin. M.S. Thesis. University of Wisconsin, Stevens Point. 63 pp.

Aldous, S. E. 1943. Sharp-tailed grouse in the sand dune country of north-central North Dakota. J. Wildl. Manage. 7:23–31.

Allen, J. A. 1874. Notes on the natural history of portions of Dakota and Montana Territories, being the substance of a report to the Secretary of War on the collections made by the North Pacific Railroad Expedition of 1873, Gen. D. S. Stanley, Commander. Proc. Boston Soc. Nat. Hist. 17:33–86.

Allen, J. N. 1980. The ecology and behavior of the long-billed curlew in southeastern Washington. Wildl. Monogr. 73. 67 pp.

American Ornithologists' Union. 1957. Check-list of North American birds. Fifth edition (suppl.). Port City Press, Baltimore. 691 pp.

Austin, G. T. 1976. Behavioral adaptations of the verdin to the desert. Auk 93:245–262.

Bailey, A. M., and R. J. Niedrach. 1938. The chestnut-collared longspur in Colorado. Wilson Bull. 50:243–246.

Bailey, A. M., and R. J. Niedrach. 1965. Birds of Colorado. Denver Museum of Natural History. 2 vol.

Bailey, F. M. 1915a. Characteristic birds of the North Dakota prairies. I. In the open grassland. Condor 17:173–179.

Bailey, F. M. 1915b. Characteristic birds of the Dakota prairies. II. Along the lake borders. Condor 17:222–226.

Bailey, F. M. 1915c. A family of North Dakota marsh hawks. Bird-Lore 17:431–438.

Bailey, F. M. 1918. A return to the Dakota lake region. II. Birds of the unbroken prairie. Condor 20:110–114.

Baldwin, P. H. 1956. Breeding record of the Brewer's sparrow in northwestern Montana. Wilson Bull. 68:251.

Barr, A. J., J. H. Goodnight, J. P. Sall, and J. T. Helwig. 1976. A user's guide to SAS 76. SAS Institute Inc., Raleigh.

Beecher, W. J. 1942. Nesting birds and the vegetation substrate. Chicago Ornithological Society, Chicago. 69 pp.

Belcher, M. 1961. Birds of Regina. Sask. Nat. Hist. Soc. Spec. Publ. 3. 76 pp.

Benckeser, H. R. 1957. Keith County notes. Nebr. Bird Rev. 25:24-25.

Bendire, C. 1895. Life histories of North American birds. U.S. Natl. Mus. Spec. Bull. 3. 518 pp.

Bent, A. C. 1929. Life histories of North American shore birds. Part 2. U.S. Natl. Mus. Bull. 146. 412 pp.

Bent, A. C. 1958. Life histories of North American blackbirds, orioles, tanagers, and allies. U.S. Natl. Mus. Bull. 211. 549 pp.

Bernhoft, L. S. 1969. Reproductive ecology of female sharp-tailed grouse (*Pedioecetes phasianellus jamesii* Lincoln) and food habits of broods in southwestern North Dakota. M.S. Thesis. University of North Dakota, Grand Forks. 96 pp.

Bicak, T. K. 1977. Some eco-ethological aspects of a breeding population of long-billed curlews (*Numenius americanus*) in Nebraska. Proc. Nebr. Acad. Sci. Affil. Soc. 87:7.

Bird, R. D., and L. B. Smith. 1964. The food habits of the red-winged blackbird (*Agelaius phoeniceus*) in Manitoba. Can. Field-Nat. 78:179-186.

Bluemle, J. P. 1977. The face of North Dakota—the geologic story. N.D. Geol. Surv. Educ. Ser. 11. 73 pp.

Boyd, R. L. 1974. Thirty-eighth breeding bird census. 1974: Short-grass prairie. Am. Birds 28:1029-1030.

Boyd, R. L. 1977. Behavioral biology and energy expenditure in a horned lark population. Ph.D. Thesis. Colorado State University, Fort Collins. 194 pp.

Bradbury, W. C. 1918. Notes on the nesting of the mountain plover. Condor 20:157-163.

Braun, C. E., M. F. Baker, R. L. Eng, J. S. Gashwiler, and M. H. Schroeder. 1976. Conservation committee report of effects of alteration of sagebrush communities on the associated avifauna. Wilson Bull. 88:165-171.

Breckenridge, W. J. 1943. Notes on natural history—the private life of a marsh hawk. Conserv. Volunteer 5(29):15-18.

Brown, R. L. 1966. Response of sharptail breeding populations to annual changes in residual grassland cover. Proc. West. Assoc. State Game Fish Comm. 46:219-222.

Bue, G. T. 1955. Recent observations of burrowing owls in Lyon and Yellow Medicine counties, Minnesota. Flicker 27:40-41.

Bunni, M. K. 1959. The killdeer, *Charadrius vociferus* Linnaeus, in the breeding season: ecology, behavior, and the development of homoiothermism. Ph.D. Thesis. University of Michigan, Ann Arbor. 306 pp.

Buss, I. O., and A. S. Hawkins. 1939. The upland plover at Faville Grove, Wisconsin. Wilson Bull. 51:202-220.

Butterfield, J. D., P. D. Creighton, and P. H. Baldwin. 1969. Summer ecology of the lark bunting. Int. Biol. Programme Grassland Biome Tech. Rep. 29. 37 pp.

Butts, K. O. 1973. Life history and habitat requirements of burrowing owls in western Oklahoma. M.S. Thesis. Oklahoma State University, Stillwater. 188 pp.

Canada Surveys and Mapping Branch, Geography Division. 1974. The National Atlas of Canada. 4th ed. Macmillan, Toronto. 254 pp.

Cantwell, G. G. 1889. Notes from Minnesota. Auk 6:340-341.

Cartwright, B. W., T. M. Shortt, and R. D. Harris. 1937. Baird's sparrow. Trans. R. Can. Inst. 21: 153

Cary, M. 1902. Some general remarks upon the distribution o[illegible] in northwest Nebraska. Proc. Nebr. Ornithol. Union 3:63-75.

Christenson, C. D. 1970. Nesting and brood characteristics of sharp-tailed grouse (*Pedioecetes phasianellus jamesii* Lincoln) in southwestern North Dakota. M.S. Thesis. University of North Dakota, Grand Forks. 53 pp.

Clark, R. J. 1972. Observations of nesting marsh hawks in Manitoba. Blue Jay 30:43-48.

Cody, M. L. 1968. On the methods of resource division in grassland bird communities. Am. Nat. 102:107-147.

Cody, M. L. 1974. Competition and the structure of bird communities. Princeton University Press, Princeton. 318 pp.

Cole, T., and R. S. Sharpe. 1976. The effects of grazing management on a sandhills prairie community. III. Breeding bird density and diversity. Proc. Nebr. Acad. Sci. Affil. Soc. 86:12.

Cook, R. E. 1969. Variation in species density of North American birds. Syst. Zool. 18:63-84.

Coues, E. 1878. Field notes on birds observed in Dakota and Montana along the forty-ninth parallel during the seasons of 1873 and 1874. Bull. U.S. Geol. Geog. Surv. Territories 4:545-661.

Creighton, P. D. 1971. Nesting of the lark bunting in north-central Colorado. Int. Biol. Programme Tech. Rep. 68. 17 pp.

Creighton, P. D., and P. H. Baldwin. 1974. Habitat exploitation by an avian ground foraging guild. Int. Biol. Programme Grassland Biome Tech. Rep. 263. 139 pp.

Criddle, N. 1912. Popular and practical ornithology. III. The upland plover. Ottawa Nat. 26:61-65.

Currie, R. P. 1892. The chestnut-collared longspur. Oologist 9:243-244.

Downing, R. L. 1957. An evaluation of ground nesting by mourning doves in northwestern Oklahoma. M.S. Thesis. Oklahoma State University, Stillwater. 33 pp.

DuBois, A. D. 1931. Songs of the Baird sparrow. Condor 33:202-203.

DuBois, A. D. 1935. Nests of horned larks and longspurs on a Montana prairie. Condor 37:56-72.

DuBois, A. D. 1937. Notes on coloration and habits of the chestnut-collared longspur. Condor 39:104-107.

BEST DOCUMENT AVAILABLE

Duebbert, H. F., and J. T. Lokemoen. 1977. Upland nesting of American bitterns, marsh hawks, and short-eared owls. Prairie Nat. 9:33-40.

Dumas, P. C. 1950. Habitat distribution of breeding birds in southeastern Washington. Condor 52:232-237.

Duncan, M. B. 1955. Multiple range and multiple F tests. Biometrics 11:1-42.

Ellison, L. 1960. The influence of grazing on plant succession of rangelands. Bot. Rev. 26:1-78.

Evans, K. E. 1968. Characteristics and habitat requirements of the greater prairie chicken and sharp-tailed grouse—a review of the literature. U.S. For. Serv., Conserv. Res. Rep. 12. 32 pp.

Fairbanks, R. L., C. R. Legros, D. S. Thorne, and J. K. McBride. 1977. Breeding bird populations of selected grassland and weedy fields in north-central Colorado. Am. Birds 31:64-67.

Fairfield, G. M. 1962. Uncultivated prairie grassland. Audubon Field Notes 16:531.

Feist, F. G. 1968. Breeding populations in relation to proposed sagebrush control in central Montana. M.S. Thesis. Montana State University, Bozeman. 41 pp.

Felske, B. E. 1971. The population dynamics and productivity of McCown's longspur at Matador, Saskatchewan. M.S. Thesis. University of Saskatchewan, Saskatoon. 133 pp.

Fenneman, N. M. 1931. Physiography of western United States. McGraw-Hill Co., New York. 534 pp.

Ferry, J. F. 1910. Birds observed in Saskatchewan during the summer of 1909. Auk 27:185-204.

Finzel, J. E. 1964. Avian populations of four herbaceous communities in southeastern Wyoming. Condor 66:496-510.

Francis, W. J. 1973. Blackbird nest placement and nesting success. Wilson Bull. 85:86-87.

Friedmann, H. 1929. The cowbirds. Charles C Thomas, Springfield. 421 pp.

Furniss, O. C. 1933. Observations on the nesting of the killdeer plover in the Prince Albert district of central Saskatchewan. Can. Field-Nat. 47:135-138.

George, R. R., A. L. Farris, C. C. Schwartz, D. D. Humburg, and J. C. Coffey. 1979. Native prairie grass pastures as nest cover for upland birds. Wildl. Soc. Bull. 7:4-9.

Giezentanner, J. B. 1970. Avian distribution and population fluctuations on the shortgrass prairie of north-central Colorado. Int. Biol. Programme Tech. Rep. 62. 112 pp.

Girard, G. L. 1937. Life history, habits, and food of the sage grouse, *Centrocercus urophasianus* Bonaparte. Univ. Wyo. Publ. 3:1-56.

Gleason, R. S. 1978. Aspects of the breeding biology of burrowing owls in southeastern Idaho. M.S. Thesis. University of Idaho, Moscow. 47 pp.

Godfrey, W. E. 1950. Birds of the Cypress Hills and Flotten Lake Regions, Saskatchewan. Natl. Mus. Can. Bull. 120. 96 pp.

Graul, W. D. 1973. Adaptive aspects of the mountain plover social system. Living Bird 12:69-94.

Graul, W. D. 1975. Breeding biology of the mountain plover. Wilson Bull. 87:6-31.

Graul, W. D. 1980. Grassland management practices and bird communities. Pages 38-47 *in* R. M. DeGraff and N. G. Tilghman, compilers. Management of western forests and grasslands for nongame birds. U.S. For. Serv. Gen. Tech. Rep. INT-86.

Graul, W. D., and L. E. Webster. 1976. Breeding status of the mountain plover. Condor 78:265-267.

Great Plains Flora Association. 1977. Atlas of the flora of the Great Plains. Iowa State University Press, Ames. 600 pp.

Grinnell, J., and A. H. Miller. 1944. The distribution of the birds of California. Pac. Coast Avifauna 27. 608 pp.

Grinnell, J., and T. I. Storer. 1924. Animal life in the Yosemite. Univ. of California Press, Berkeley. 752 pp.

Gross, A. O. 1940. Eastern nighthawk. Pages 206-234 in A. C. Bent. Life histories of North American cuckoos, goatsuckers, hummingbirds, and their allies. U.S. Nat. Mus. Bull. 176.

Hahn, H. W. 1941. The cowbird at the nest. Wilson Bull. 53:211-221.

Hamilton, W. J., Jr. 1941. A note on the food of the western burrowing owl. Condor 43:74.

Harris, R. D. 1944. The chestnut-collared longspur in Manitoba. Wilson Bull. 56:105-115.

Harrison, K. G. 1974. Aspects of habitat selection in grassland birds. M.A. Thesis. Western Michigan University, Kalamazoo. 82 pp.

Harrold, C. G. 1933. Notes on the birds found at Lake Johnston and Last Mountain Lake, Saskatchewan, during April and May, 1922. Wilson Bull. 45:16-26.

Hayden, F. V. 1863. On the geology and natural history of the upper Missouri. Trans. Am. Philos. Soc. 12:151-176.

Hibbard, E. A. 1965. Comments on the distribution and abundance of the lark bunting and other prairie fringillids in Minnesota and North Dakota. Loon 37:70-72.

Hibbard, E. A. 1972. Burned and unburned prairie surveys 97, 98. Am. Birds 26:1004-1005.

Hillman, C. N., and W. W. Jackson. 1973. The sharp-tailed grouse in South Dakota. S.D. Dep. Game Fish Parks, Tech. Bull. 3. 64 pp.

Hoffman, W. J. 1877. List of birds observed at Grand River Agency, Dakota Territory, from October 7th, 1872, to June 7th, 1873. Proc. Boston Soc. Nat. Hist. 18:169-175.

Holcomb, L. C., and G. Twiest. 1968. Ecological factors affecting nest building in red-winged blackbirds. Bird-Banding 39:14-22.

Hopkins, R. B. 1980. Mixed Prairie I. Am. Birds 34:67-68.

Hoskin, H. G. 1893. Nesting of the mountain plover. Oologist 10:240.

Houston, C. S. 1981. An assessment of Walter Raine and his Saskatchewan records. Blue Jay 39:168-181.

Humphrey, R. R. 1962. Range ecology. Ronald Press, New York. 234 pp.

Hyde, A. S. 1939a. The life history of Henslow's sparrow, *Passerherbulus henslowi* (Audubon). Univ. Mich. Misc. Publ. 41. 72 pp.

Hyde, A. S. 1939*b*. The ecology and economics of the birds along the northern boundary of New York State. Roosevelt Wildl. Bull. 7(2):62–215.

Johnsgard, P. A. 1955. The relation of water level and vegetational change to avian populations, particularly waterfowl. M.S. Thesis. State College of Washington, Pullman. 167 pp.

Johnsgard, P. A., and W. H. Rickard. 1957. The relation of spring bird distribution to a vegetation mosaic in southeastern Washington. Ecology 38:171–174.

Johnson, D. H. 1972. Breeding bird populations of selected grasslands in east-central North Dakota. Am. Birds 26:971–975.

Johnson, D. H. 1973. Breeding bird populations of selected grasslands in east-central North Dakota. Am. Birds 27:989–990.

Johnson, D. H. 1974. Breeding bird populations of selected grasslands in east-central North Dakota. Am. Birds 28:1030–1031.

Kaiser, G. W., L. P. Lefkovitch, and H. F. Howden. 1972. Faunal provinces in Canada as exemplified by mammals and birds: a mathematical consideration. Can. J. Zool. 50:1087–1104.

Kantrud, H. A. 1981. Grazing intensity affects the breeding avifauna of North Dakota native grasslands. Can. Field-Nat. 95(4).

Karasiuk, D., H. Vriend, J. G. Stelfox, and J. R. McGillis. 1977. Study results from Suffield, 1976. Pages E33–E44 *in* J. G. Stelfox, compiler. Effects of livestock grazing on mixed prairie range and wildlife within PFRA pastures, Suffield Military Reserve. Range Wildlife Study Commission, Canadian Wildlife Service, Edmonton.

Kendeigh, S. C. 1941. Birds of a prairie community. Condor 43:165–174.

Kikkawa, J. 1968. Ecological association of bird species and habitats in eastern Australia; similarity analysis. J. Anim. Ecol. 37:143–165.

King, R. 1978. Habitat use and related behaviors of breeding long-billed curlews. M.S. Thesis. Colorado State University, Ft. Collins. 69 pp.

Kirsch, L. M., and K. F. Higgins. 1976. Upland sandpiper nesting and management in North Dakota. Wildl. Soc. Bull. 4:16–20.

Kirsch, L. M., A. T. Klett, and H. W. Miller. 1973. Land use and prairie grouse population relationships in North Dakota. J. Wildl. Manage. 37:449–453.

Knapton, R. W. 1978. Breeding ecology of the clay-colored sparrow. Living Bird 17:137–158.

Knapton, R. W. 1979. Birds of the Gainsborough-Lyleton region. Sask. Nat. Hist. Soc. Spec. Publ. 10. 72 pp.

Kobriger, G. D. 1965. Status, movements, habitats, and foods of prairie grouse on a sandhills refuge. J. Wildl. Manage. 29:788–800.

Kohn, S. C. 1976. Sharp-tailed grouse nesting and brooding habitat in southwestern North Dakota. M.S. Thesis. South Dakota State University, Brookings. 83 pp.

Krapu, G. L. 1978. Productivity of red-winged blackbirds in prairie pothole habitat. Iowa Bird Life 48:24–30.

Krause, H. 1968. McCown's longspur. Pages 1564–1597 *in* O. L. Austin Jr., ed. Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows and allies. Part 3. U. S. Natl. Mus. Bull. 237.

Kuchler, A. W. 1964. Potential natural vegetation of the conterminous United States. American Geographical Society, New York. 39 pp. + 116 plates.

Lane, J. 1968. Baird's sparrow. Pages 745–765 *in* O. L. Austin Jr., ed. Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies. Part 2. U.S. Natl. Mus. Bull. 237.

Lardy, M. E. 1980. Raptor inventory and ferruginous hawk breeding biology in southeastern Oregon. M.S. Thesis. University of Idaho, Moscow. 53 pp.

LaRivers, I. 1944. Observations on the nesting mortality of the Brewer blackbird, *Euphagus cyanocephalus*. Am. Midl. Nat. 32:417–437.

Laun, H. C. 1957. A life history study of the mountain plover, *Eupoda montana*, Townsend on the Laramie Plains, Albany County, Wyoming. M.S. Thesis. University of Wyoming, Laramie. 67 pp.

Lein, M. R. 1968. The breeding biology of the savannah sparrow, *Passerculus sandwichensis* (Gmelin) at Saskatoon, Saskatchewan. M.A. Thesis. University of Saskatchewan, Saskatoon. 171 pp.

Lincoln, F. C. 1925. Notes on the bird life of North Dakota with particular reference to the summer waterfowl. Auk 42:50–64.

Lock, R. A. 1975. Young mountain plover seen in Kimball County, Nebr. Bird Rev. 43:54–56.

Lohoefener, R. 1978. Summer observations of the mountain plover in southwest South Dakota. S.D. Bird Notes 30:30, 38–39.

Lohoefener, R., and C. A. Ely. 1978. The nesting birds of LaCreek National Wildlife Refuge. S.D. Bird Notes 30:24–30.

Lokemoen, J. T., and H. F. Duebbert. 1974. Summer birds for a South Dakota prairie. S.D. Conserv. Digest 41:18–21.

Lokemoen, J. T., and H. F. Duebbert. 1976. Ferruginous hawk nesting ecology and raptor populations in northern South Dakota. Condor 78:464–470.

Longhurst, W. M. 1942. The summer food of burrowing owls in Costilla County, Colorado. Condor 44:281–282.

Maher, W. J. 1972. Growth of ground-nesting passerine birds at Matador, Saskatchewan, Canada. Pages 85–102 *in* J. Pinowski and S. C. Kendeigh, eds. Granivorous birds in ecosystems, their evolution, populations, energetics, adaptations, impact and control. Cambridge University Press, New York.

Maher, W. J. 1973. Birds: I. Population dynamics. Int. Biol. Programme Matador Project. Tech. Rep. 34. 56 pp.

Maher, W. J. 1979. Nestling diets of prairie passerine birds at Matador, Saskatchewan, Canada. Ibis 121:437–452.

Maher, W. J., and B. Felske. 1970. Avian studies at Matador. Pages 86–88 *in* R. T. Coupland and G. M. Van Dyne, eds. Grassland ecosystems: reviews of research. Colo. State Univ. Range Sci.

Dep., Range Sci. Ser. 7.

Martin, D. J. 1973. Selected aspects of burrowing owl ecology and behavior. Condor 75:446-456.

Martin, S. G. 1971. Polygyny in the bobolink: habitat quality and the adaptive complex. Ph.D. Thesis. Oregon State University, Corvallis. 181 pp.

Mattise, S. N. 1978. Effects of grazing systems on sharp-tailed grouse habitat. M.S. Thesis. South Dakota State University, Brookings. 29 pp.

McGee, J. M. 1976. Some effects of fire suppression and prescribed burning on birds and small mammals in sagebrush. Ph.D. Thesis. University of Wyoming, Laramie. 145 pp.

Meents, J. K. 1979. Avian community structure in Chihuahuan desert grasslands. Ph.D. Thesis. New Mexico State University, Las Cruces. 60 pp.

Miller, R. S. 1968. Conditions of competition between redwings and yellowheaded blackbirds. J. Anim. Ecol. 37:43-62.

Mitchell, G. J. 1967. The upland plover and its status in relation to environmental conditions and situations, past and present. Blue Jay 25:58-63.

Monson, G. 1941. The effect of revegetation on the small bird population in Arizona. J. Wildl. Manage. 5:395-397.

Neilson, J. A. 1923. Notes on killdeer in southeastern Wyoming. Oologist 15:13-14.

Newell, W. 1950. Notes on the nesting activities of the marsh hawk. Nebr. Bird Rev. 18:16-17.

Olendorff, R. R. 1972. The large birds of prey of the Pawnee National Grassland: nesting habits and productivity, 1969-71. Int. Biol. Programme Grassland Biome Tech. Rep. 151. 59 pp.

Olson, R. A. 1974. Bird populations in relation to changes in land use in Curlew Valley, Idaho and Utah. M.S. Thesis. Idaho State University, Pocatello. 40 pp.

Orians, G. H. 1961. The ecology of blackbird (*Agelaius*) social systems. Ecol. Monogr. 31:285-312.

Orians, G. H., and H. S. Horn. 1969. Overlap in foods and foraging of four species of blackbirds in the potholes of central Washington. Ecology 50:930-938.

Overmire, T. G. 1963. The effects of grazing upon habitat utilization of the dickcissel (*Spiza americana*) and Bell's vireo (*Vireo bellii*) in northcentral Oklahoma. Ph.D. Thesis. Oklahoma State University, Stillwater. 65 pp.

Owens, R. A., and M. T. Myres. 1973. Effects of agriculture upon populations of native passerine birds of an Alberta fescue grassland. Can. J. Zool. 51:697-713.

Pampush, G. J. 1980. Breeding chronology, habitat utilization and nest site selection of the long-billed curlew in northcentral Oregon. M.S. Thesis. Oregon State University, Corvallis. 49 pp.

Patterson, R. L. 1952. The sage grouse in Wyoming. Sage Books, Denver. 341 pp.

Patton, F. A. 1926. Burrowing owls, horned larks. Oologist 43:14.

Peabody, P. B. 1899. Clay-colored sparrow. Oologist 16:177-180.

Peabody, P. B. 1900. *Cyanocephalus* the obscure. Warbler 5:15-20.

Pepper, G. W. 1972. The ecology of sharp-tailed grouse during spring and summer in the aspen parklands of Saskatchewan. Sask. Dep. Nat. Resour. Wildl. Rep. 1. 56 pp.

Peters, A. S. 1923. Bird notes from Ward County, North Dakota. Oologist 40:103-104.

Pleszczynska, W. K. 1978. Microgeographic prediction of polygyny in the lark bunting. Science 201:935-937.

Potter, P. E. 1972. Territorial behavior in savannah sparrows in southeastern Michigan. Wilson Bull. 84:48-59.

Potter, P. E. 1974. Breeding behavior of savannah sparrows in southeastern Michigan. Jack-Pine Warbler 52:50-63.

Provost, M. W. 1947. Nesting of birds in the marshes of northwest Iowa. Am. Midl. Nat. 38:485-503.

Rabinovich, J. E., and E. H. Rapoport. 1975. Geographical variation of diversity in Argentine passerine birds. J. Biogeogr. 2:141-157.

Rand, A. L. 1948. Birds of southern Alberta. Natl. Mus. Can. Bull. 111. 105 pp.

Rasmussen, D. I., and L. A. Griner. 1938. Life history and management studies of the sage grouse in Utah, with special reference to nesting and feeding habits. Trans. N. Am. Wildl. Conf. 3:852-864.

Renaud, W. E. 1980. The long-billed curlew in Saskatchewan: status and distribution. Blue Jay 38:221-237.

Renaud, W. E., and D. H. Renaud. 1975. Birds of the Rosetown-Biggar District, Saskatchewan. Sask. Nat. Hist. Soc. Spec. Publ. 9. 121 pp.

Reynolds, T. D., and T. D. Rich. 1978. Reproductive ecology of the sage thrasher (*Oreoscoptes montanus*) on the Snake River Plain in south-central Idaho. Auk 95:580-582.

Reynolds, T. D., and C. H. Trost. 1980. The response of native vertebrate populations to crested wheatgrass planting and grazing by sheep. J. Range Manage. 33:122-125.

Ricklefs, R. E., and F. R. Hainsworth. 1969. Temperature regulation in nestling cactus wrens: The nest environment. Condor 71:32-37.

Robbins, C. S., and W. T. Van Velzen. 1967. The breeding bird survey, 1966. U.S. Fish Wildl. Serv., Spec. Sci. Rep. - Wildl. 102. 43 pp.

Roberts, T. S. 1932. The birds of Minnesota. University of Minnesota Press, Minneapolis. 2 vols.

Rogers, G. E. 1964. Sage grouse investigations in Colorado. Colo. Game Fish Parks Dep., Tech. Publ. 16. 132 pp.

Roosevelt, T. 1885. Hunting trips of a ranchman. G. P. Putnam's Sons, New York. 2 vols.

Root, O. M. 1968. Clay-colored sparrow. Pages 1186-1208 *in* O. L. Austin Jr., ed. Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies. Part 2. U.S. Natl. Mus. Bull. 237.

Rotenberry, J. T. 1978. Components of avian diversity along a multifactorial climatic gradient. Ecology 59:693-699.

Rotenberry, J. T., and J. T. Wiens. 1980. Habitat structure, patchiness, and avian communities in North American steppe vegetation: a multivariate analysis. Ecology 61:1228-1250.

BEST DOCUMENT AVAIL

Rowan, W. 1926. Notes on Alberta waders included in the British List. Brit. Birds 20:2-10.

Roy, J. F. 1964. An introduction to the birds of the Elbow. Saskatchewan Natural History Society, Regina. 33 pp.

Ryder, R. A. 1970. Avian populations at the Pawnee site. Pages 89-91 *in* R. T. Coupland and G. M. Van Dyne, eds. Grassland ecosystems: reviews of research. Colo. State Univ. Range Sci. Dep., Range Sci. Ser. 7.

Ryder, R. A. 1980. Effects of grazing on bird habitats. Pages 51-66 *in* R. M. DeGraff and N. G. Tilghman, compilers. Management of western forests and grasslands for nongame birds. U.S. For. Serv. Gen. Tech. Rep. INT-86.

Ryder, R. A., and M. A. Strong. 1971. Censuses of avian populations at the Pawnee site, Colorado, under the International Biological Program. Proc. West. Assoc. State Game Fish Comm. 51:363-377.

Salt, W. R. 1966. A nesting study of *Spizella pallida*. Auk 83:274-281.

Salt, W. R., and J. R. Salt. 1976. The birds of Alberta. Hurtig Publishers, Edmonton. 498 pp.

Saunders, A. A. 1913. A study of the nesting of the marsh hawk. Condor 15:99-104.

Saunders, A. A. 1914. The birds of Teton and northern Lewis and Clark counties, Montana. Condor 16:124-144.

Saunders, A. A. 1921. A distributional list of the birds of Montana, with notes on the migration and nesting of the better known species. Pac. Coast Avifauna 14. 194 pp.

Schall, J. J., and E. R. Pianka. 1978. Geographical trends in numbers of species. Science 201:679-686.

Sclater, W. H. 1912. A history of the birds of Colorado. Witherby & Co., London. 576 pp.

Scott, O. K., H. H. Scott, and C. K. Scott. 1964. Sagebrush foothills. Audubon Field Notes 18:562-563.

Scott, T. G., and C. H. Wasser. 1980. Checklist of North American plants for wildlife biologists. The Wildlife Society, Washington, D.C. 58 pp.

Sealy, S. G. 1967. Notes on the breeding biology of the marsh hawk in Alberta and Saskatchewan. Blue Jay 25:63-69.

Sherman, A. R. 1932. Red-winged blackbirds nesting in treetops near top of hill. Auk 49:358.

Sibley, C. G., and O. S. Pettingill, Jr. 1955. A hybrid longspur from Saskatchewan. Auk 72:423-425.

Silloway, P. M. 1900. Notes on the long-billed curlew. Condor 2:79-82.

Silloway, P. M. 1902. Some experiences of 1901. Condor 4:31-34.

Silloway, P. M. 1903. Birds of Fergus County, Montana. Fergus County Free High School, Bull. 1. 77 pp.

Silloway, P. M. 1904. Extracts from some Montana note books, 1904. Condor 6:148-150.

Silloway, P. M. 1917. Some interesting birds of the Judith Basin, Montana. Oologist 34:156, 158-160.

Sisson, L. 1976. The sharp-tailed grouse in Nebraska. Nebraska Game and Parks Commission, Lincoln. 88 pp.

Skinner, R. M. 1975. Grassland use patterns and prairie bird populations in Missouri. Pages 171-180 *in* M. K. Wali, ed. Prairie: A multiple view. University of North Dakota Press, Grand Forks.

Smith, A. R. 1977. Comparable results from similar areas at Matador, Saskatchewan and Hand Hills, Alberta. Pages E45-E54 *in* J. G. Stelfox, compiler. Effects of livestock grazing on mixed prairie range and wildlife within PFRA pastures, Suffield Military Reserve. Range-Wildlife Study Commission, Canadian Wildlife Service, Edmonton.

Smith, C. C. 1940. The effect of overgrazing and erosion upon the biota of the mixed-grass prairie of Oklahoma. Ecology 21:381-397.

Soper, J. D. 1941. The mountain plover in western Canada. Can. Field-Nat. 55:137.

South Dakota Ornithologists' Union. 1978. Birds of South Dakota. W. H. Over Museum, Vermillion. 311 pp.

Soutiere, E. C., and E. G. Bolen. 1976. Mourning dove nesting on tobosa grass-mesquite rangeland sprayed with herbicides and burned. J. Range Manage. 29:226-231.

Speirs, J. M., and R. Orenstein. 1967. Bird populations in fields of Ontario County, 1965. Can. Field-Nat. 81:175-183.

Stewart, R. E. 1975. Breeding birds of North Dakota. Tri-college Center for Environmental Studies, Fargo. 295 pp.

Stewart, R. E., and H. A. Kantrud. 1972. Population estimates of breeding birds in North Dakota. Auk 89:766-788.

Sugden, J. W. 1933. Range restriction of the long-billed curlew. Condor 35:3-9.

Taylor, W. P. 1912. Field notes on amphibians, reptiles, and birds of northern Humboldt County, Nevada, with a discussion of some of the faunal features of the region. Univ. Calif. Publ. Zool. 7:319-436.

Terent'ev, P. V. 1963. Attempt at application of analysis of variation to the qualitative richness of the fauna of terrestrial vertebrates of the U.S.S.R. Vest. Leningr. Univ. No. 21:19-26 (transl. Smithsonian Herpetol. Inform. Serv. 1968).

Tester, J. R., and W. H. Marshall. 1961. A study of certain plant and animal interrelations on a native prairie in northwestern Minnesota. Univ. Minn. Mus. Nat. Hist. Occas. Pap. 8. 51 pp.

Thompson, E. E. 1890. The birds of Manitoba. Proc. U.S. Natl. Mus. 13:457-643.

Thompson, L. S., and D. Sullivan. 1979. Breeding birds of prairie grassland and shrubland habitats in northeastern Montana, 1978. Am. Birds 33:88-89.

Timken, R. L. 1969. Notes on the long-billed curlew. Auk 86:750-751.

Todd, W. E. C. 1947. Notes on the birds of southern Saskatchewan. Ann. Carnegie Mus. 30:383-421.

Trost, C. H. 1972. Adaptations of horned lark (*Eremophila alpestris*) to hot environments. Auk 89:506-527.

Tyler, J. G. 1913. Some birds of the Fresno district, California. Pac. Coast Avifauna 9. 114 pp.

U.S. Department of the Interior and Canadian Department of the Environment. 1977. Standard operating procedures for aerial waterfowl breeding ground population and habitat surveys. Section IV.

33 pp.

U.S. Geological Survey. 1970. The National Atlas of the United States of America. U.S. Department of the Interior, Washington, D.C. 417 pp.

U.S. Soil Conservation Service. 1975. Soil taxonomy. U.S. Dep. Agric. Agric. Handb. 436. 754 pp.

Visher, S. S. 1913. Corrections to a preliminary list of the summer birds of Fall River County, southwestern South Dakota. Wilson Bull. 25:38–39.

Visher, S. S. 1914. The biology of Harding County, northwestern South Dakota. S.D. Geol. Nat. Hist. Surv. Bull. 6:11–103.

Walcheck, K. C. 1970. Nesting bird ecology of four plant communities in the Missouri breaks, Montana. Wilson Bull. 82:370–382.

Wallis, C., and V. Loewen. 1980. First nesting record of the mountain plover in Canada. Alberta Nat. 10:63–64.

Wallis, C. A., and C. R. Wershler. 1981. Status and breeding of mountain plovers (*Charadrius montanus*) in Canada. Can. Field-Nat. 95:133–136.

Warren, E. R. 1912. Some north-central Colorado bird notes. Condor 14:81–104.

Whittle, C. L. 1922. Miscellaneous bird notes from Montana. Condor 24:73–81.

Wiens, J. A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithol. Monogr. 8. 93 pp.

Wiens, J. A. 1973. Pattern and process in grassland bird communities. Ecol. Monogr. 43:237–270.

Wiens, J. A. 1974. Climatic instability and the "ecological saturation" of bird communities in North American grasslands. Condor 76:385–400.

Wiens, J. A., and M. I. Dyer. 1975. Rangeland avifaunas: their composition, energetics, and role in the ecosystem. Pages 146–182 in D. R. Smith, coordinator. Symposium on management of forest and range habitats for nongame birds. U.S. For. Serv. Gen. Tech. Rep. WO-1.

Williams, L. 1958. Brewer's blackbird. Pages 302–334 in A. C. Bent. Life histories of North American blackbirds, orioles, tanagers, and allies. U.S. Natl. Mus. Bull. 211.

Williams, R. B., and C. P. Matteson, Jr. 1947. Wyoming hawks. The marsh hawk. Wyo. Wildl. 11:16–19, 36–37, 39.

Wing, L. 1949. Breeding birds of virgin palouse prairie. Auk 66:38–41.

Wood, N. A. 1923. A preliminary survey of the bird life of North Dakota. Univ. Mich. Mus. Zool. Misc. Publ. 10. 98 pp.

Woolfolk, E. J. 1945. Some observations of lark buntings and their nests in eastern Montana. Condor 47:128.

Wray, T., II, and R. C. Whitmore. 1979. Effects of vegetation on nesting success of vesper sparrows. Auk 96:802–805.

Yde, C. A. 1977. Distribution and movements of sharp-tailed grouse during spring and summer in relation to rest-rotation grazing. M.S. Thesis. Montana State University, Bozeman. 70 pp.

Youngworth, W. 1944. Bird notes from the Upper Missouri Valley in 1939. Iowa Bird Life 14:56–57.

Zarn, M. 1974. Habitat management series for unique or endangered species. Burrowing owl. U.S. Bur. Land Manage. Tech. Note 250. 25 pp.

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Wildlife Research Reports:

1. An Analysis of the Population Dynamics of Selected Avian Species with special reference to changes during the modern pesticide era, by Charles J. Henny. 1972. 99 pp.
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